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Projects such as this are unthinkable without long-term support. It began with support from the Canada Council while writing a doctoral thesis on perspective at the Warburg Institute (1971-1975). This led to an invitation from Professors Eugenio Battisti and Marisa Dalai Emiliani to prepare a bibliography for the first world conference on perspective (Milan, 1977). The discovery that Professor Luigi Vagnetti had been working independently for thirty years on a bibliography transformed the scope of the project. A generous series of fellowships from the Volkswagen, Humboldt, Thyssen and Gerda Henkel Foundations made it possible to work part-time on the bibliography at the Herzog August Bibliothek in Wolfenbüttel while doing research on Leonardo da Vinci's perspective and optics (September 1977-September 1984). Two years of teaching intervened. Support from the Getty Trust made it possible to resume the project (September 1986-June 1987), which then continued with the aid of a Canada Research Fellowship (July 1987 to June 1992).

In the course of the past decades, hundreds of individuals have contributed to the bibliography: Professors André Chastel, Decio Gioseffi, Kaori Kitao and Corrado Maltese kindly sent lists of titles and references. Particular thanks go to a handful of mentors whose interest, criticisms and counsel have helped to shape this project: Professors Eugenio Battisti, B.A.R. Carter, Samuel Y. Edgerton, Jr., Sir Ernst Gombrich and Luigi Vagnetti. Special thanks go to Professoress Marisa Dalai-Emiliani who has patiently followed and encouraged every phase of the project.

In Wolfenbüttel there were three individuals, unflinching in their support, whom I thank particularly: Professor Paul Raabe, then Director of the Herzog August Bibliothek; Dr. Sabine Solf, Leiterin des Forschungsprogramms and the late Dr. Hans-Heinrich Solf. There was also Dr. Marie-Luise Zarnitz, of the Volkswagen Foundation, who visited regularly from Hanover. At the library, Anne-Marie Deegen was exemplary in her helpfulness. Ulrich Kopp gave advice. Gaby (né Jöckel) Lüddecke, heroically ordered seven meters of photocopies through interlibrary loan. Uwe Jumtow, and subsequently Miss Schultze, kindly drove me to Göttingen and helped in the search. At the Niedersächsische Staats-und Universitätsbibliothek Messieurs Grobe and Münther patiently introduced me to standard reference works (Art Index, Répertoire d'Art and R.I.L.A.); national book catalogues (Brinkmans, Estreicher, Lorenz, Pagliaini, etc.); then, via the mysteries of the 800-volume Real-Katalog, to specialized bibliographies (Draud, Lipenius, Murr, Murhard, Riccardi and thirty others, listed in Sources, Index 1.A.). Reimar Eck, head of user services, was tireless in his patient help and counsel.

By August 1986, the bibliography was based on the lists of 125 libraries. In addition books and journals had been consulted in 34 libraries, particularly Göttingen, Leiden, London, Madrid, Paris, Rome and Wolfenbüttel. Cooperating libraries, plus many of the librarians who helped to find or answer queries concerning rare and spurious works are listed in the Sources (Index 1.C).

As the information arrived it was transferred to handwritten file cards. In August 1986, Dr. Richard Dolen began preparing a preliminary programme which permitted the information to be entered into an IBM PCAT using a DBase III Plus system. At the Getty Center, the 15,000 titles were entered into a machine largely by Coley Grundmann and partly by Joseph Leon, with some help from Victor Bonino and Clay Stalls, two research assistants (September 1986-June 1987). Since then the computer version has continued to develop with the help of Alan Brolly (1987-1989), Paul Chvostek (1990), Jerry Szazman (1991-1992), with graphics by Eric R. Dobbs (1990-1991).
To write the *Sources* (vol.1) took three years (1987-1990); to write the *Literature* (vol. 3) has taken another four years (1990-1994). A number of scholars have kindly read drafts or sections of the typescript: Professors B.A.R. Carter, André Corboz, M. Dalai Emiliani, Samuel Edgerton Jr., Sir Ernst Gombrich, and Rocco Sinisgalli.

The larger vision underlying this project owes much to my friend, Dr. Rolf Gerling (Zürich), who in the spring of 1981 generously took me on a three-month tour of the Mediterranean. As he drove the range rover its 12,000 miles from the straits of Gibraltar, through the mountains and plains of Tunisia, Sicily and Greece, along the coasts to Tarsus and finally back across the vast expanses of Turkey, he played Socrates, and challenged me to articulate a new approach to knowledge. Other friends, Udo Jauernig (Wolfenbüttel), and Ian Stuart (London) listened many hours, as this approach gradually evolved into a multivalent bibliography. In the spring of 1986 a series of three lectures at Brigham Young University, generously arranged by my friend Professor Dan Blickman, helped clarify my ideas, as did a lecture with the Gesellschaft für Klassifikation in Münster arranged by Dr. Ingetraut Dahlberg. In Toronto my ideas were further developed with my colleague, Professor Ian Hacking, and friend, Sergio Sismondo, Jr. This led to the idea of collecting systematically all material in the field in the form of a knowledge package which was first presented at two world conferences (Toronto and Milan, May 1991). Eric Dobbs helped in that process.

Between the preparations in London, the ideas in Wolfenbüttel and their accomplishment in Santa Monica and Toronto lay the vision of Dr. Kurt Forster, Director of the Getty Center for the History of Art and the Humanities as well as the generous support of the Getty Trust (1986-1987); the encouragement of Professor M. P. Winsor, Director of the Institute for the History and Philosophy of Science and Technology (1987-1990) and Professor Derrick de Kerckhove, Director of the McLuhan Program in Culture and Technology, (1990-1993) and support from the Social Sciences and Humanities Research Council of Canada (1987-1991); and from BSO/Origin (1991-1994). Throughout there was also the loyal encouragement of my student, Barbara Keyser and friends, particularly Professors Sydney Eisen, Brayton Polka, Deirdre Vincent, Dr. Pauline and Don McGibbon and Diane Everett. I am very grateful to each person who has helped and encouraged me in the course of many years.
INTRODUCTION

This is the third part of a four volume study. Just as Sources of Perspective (vol. 1) surveys primary literature (c. 8000 titles) listed in the Bibliography of the Sources of Perspective (vol.2); the present volume, Literature on Perspective (vol. 3), surveys secondary literature (c. 7,000 titles) listed in the Bibliography of the Literature on Perspective (vol.4). The modern distinction between primary and secondary literature, i.e. between original texts and historical studies, while theoretically clear, is sometimes problematic in practice. Fifteenth and sixteenth century treatises frequently involve both categories. For instance, Filarete's Treatise on Architecture, contains technical instructions how to draw in perspective and historical reflections concerning Brunelleschi. In such cases the full title is usually listed once in the most appropriate bibliography (vol. 2), while reference is made to it in both the survey of Sources (vol. 1) and Literature (vol. 3).

This volume opens with a survey of debates concerning the origins of perspective. An outline of early theories is given, followed by the contributions of various disciplines including philosophy, art history, psychology, social science, Marxism and the studies of the history of printing. New approaches are suggested by considering different stages of development and different media. In terms of art history the role of narrative is re-assessed. In terms of history of science the interplay of optics, mathematics and science is explored in conjunction with instruments. It is shown that these developments brought new links between observation and representation; that the origins of perspective are in fact linked with a re-definition of knowledge itself that began in the latter half of the thirteenth century.

A second chapter examines literature on the history of perspective in terms of major chronological periods: pre-history; Greek and Roman, Mediaeval, Renaissance, Baroque, Eighteenth, Nineteenth and Twentieth Centuries. In the interests of clarity work on individual practitioners and theorists has been relegated to alphabetical lists in appendixes one and two in order that these can be used conveniently for reference. The historical survey includes sections on pseudo-perspectival techniques in non-western cultures, particularly China, Japan and Russia, plus a brief survey of contributions made by histories of mathematics, introductions within the treatises and bibliographies.

Chapter three turns to the history of relations between mathematics, vision and representation. Involved is a fundamental debate about the nature of perspective. Already in Antiquity there were two basic approaches to these problems. One school, championed by Plato, assumed that our knowledge of space is innate. This tradition which continued in the seventeenth century with Descartes and Malebranche has emerged as the nativist camp in America including the Gestalt school (Koffka, Arnheim) and Gibsonian school
(Gibson, Kennedy). A second approach, epitomized by Aristotle, emphasized the role of the senses, experience and learning, in the development of spatial vision and representation. This tradition continued in the Renaissance with Leonardo and found particular support among English thinkers such as Hobbes, Locke and Berkeley. This empiricist school was championed by Helmholtz in the nineteenth century and in America by Ames and the transactionalists in the twentieth century. A survey will be made of the major arguments of these schools with respect to perspective in order to consider afresh a fundamental question concerning its status: Is perspective an objective method or merely a convention?

Chapter four reviews what has been written on various technical applications of perspective. A section is devoted to scenography, inlaid wood (intarsia), ceiling painting (quadratura), trompe l'oeil, architecture, gardens and the environment respectively. Literature on alternative methods such as inverted perspective, anamorphosis, cylindrical, conical and spherical perspective is examined, as is literature on perspectival reconstructions and about perspectival instruments, such as the camera obscura and the pantograph, cameras and more recently, computers, holography and virtual reality.

The enormous significance of perspective is largely due to its metaphorical use in the sense of point of view, standpoint, or even plan. In literature the earliest examples of this metaphorical usage with respect to proto-perspective can be traced back to c. 1800 B.C., themes which are taken up again in mediaeval literature where there are interesting parallels between the rise of an individual viewpoint in both the literature and art of the French troubadours. Renaissance and baroque developments are considered, then later contributions including Goethe and Herder's reinterpretation of Shakespeare as a perspectival author, Percy Lubbock's claim (1921) that perspective in the sense of point of view should be the criterion for all literature, and recent developments in literary theory (e.g. Canisius, Guillen, Japp, Lintvelt, Uspensky). In philosophy, this metaphorical application of perspective emerged in the late seventeenth century through Leibniz. It was furthered by Kant and Hegel, yet it was mainly due to the neo-Kantians in the late nineteenth century that perspective became an important philosophical concept. The history of these philosophical developments leading to twentieth century concepts such as perspectivism and perspectivity is traced. Subsequent sections of this fifth chapter focus on the metaphorical role of perspective in other fields including ethnology, anthropology, psychology (perceptual, developmental,conceptual), with some attention to emerging fields such as perspective taking and cognitive psychology), linguistics, psychiatry, sociology and religion.

While much has been written on the role of given individuals or specific problems, there have been surprisingly few attempts to assess the implications of perspective as a whole. In the sixteenth century Vasari did so largely in terms of its importance for artistic realism. The eighteenth and nineteenth centuries brought increasing awareness of its role in mathematics. The twentieth century has seen attention to the importance of perspective for cultural history (Panofsky, Klein, Gombrich, Damish), semiotics (Saint-Martin) as well as science (Edgerton). A final chapter entitled transformations re-assesses the role of perspective in the twentieth century in an attempt to explain why perspective has become such a fundamental tool in both the production and understanding of visual and other images. Here there is emphasis on the changing role of the window in new approaches to problems of correspondence and non-correspondence.

Notes to the various chapters follow as do one hundred pages of plates which serve both to illustrate points in the text and survey some of the key attempts at perspectival reconstruction found in the secondary literature. There are five appendixes. A first lists major practitioners of perspective and reviews basic literature concerning these. A second appendix does the same for major theorists. Even a brief perusal of these studies of individual artists brings to light patterns in scholarship: for instance, that while there have
been over 120 articles on Brunelleschi and nearly a hundred on both Alberti and Piero della Francesca, there are at least 10 authors in the sixteenth century about whom almost nothing has been written (e.g. John Dee, Augustin Hirschvogel, Georg Has, or Paul Pfintzing). Appendix three surveys comments concerning foreshortening and perspective in Vasari’s *Lives of the artists* (1558). Appendix four outlines the basic categories in Lanser’s (1981) theory of perspectivity. Appendix five gives a summary of distinctive typological traits of literature found in Lintvelt (1981).

Perspective is of fundamental importance for several reasons. As a systematic method of representation it is one of the distinguishing characteristics of advanced technological societies. In the Renaissance it was an example par excellence of western achievement. Since then it has spread to most countries of the world, and brought with it a proliferation of many alternative methods, including cylindrical, conic, and spherical perspective. These alternatives have confirmed that perspective is not a technical straightjacket, but in fact our most powerful means thus far in expanding horizons of the imagination. Its methodological and metaphorical implications are therefore no coincidence. Studies during the past decades have revealed that perspective leads back to questions about the nature of drawing and representation. What is a picture? What is art? No other animal has developed anything approaching these skills. Hence perspective confronts us ultimately with one of the most basic expressions of the human condition.

To survey the literature of a field is a task as dangerous as it is thankless. Whoever attempts to be exhaustive runs the risk of plunging self and reader in nigh endless detail, while the person who aims to be selective sails between a Scylla of ignorance and a Charybdis of conscious omission. The motivations for silence are many: one may be aware of an article, recognize its derivative quality, find no pleasure in accusations of plagiarism, and choose instead to pass on without comment. On the other hand, no matter how informed one is, there will inevitably be some contributions that remain unknown to one and to which critics will draw attention. Hence, the goal of this work must lie in presenting a map of the field, providing readers with coordinates, such that they can place individual contributions within the context of a bigger picture. It is hoped that when they discover gaps and omissions they will inform this cartographer.

This is not an annotated bibliography in the sense of brief descriptions accompanying each title for three reasons: first, this has already been done by Vagnetti (1979); secondly such descriptions also frequently occur in standard art historical bibliographies such as Répertoire internationale pour la littérature d’art (RILA), the Répertoire d’art et archéologie (RAA) or since 1989 in the Bibliography for the History of Art (BHA); and third because such condensed summaries are often repetitive. Instead, this survey aims to explore the major theories and arguments in the literature on perspective: why it began, how it developed, how its applications both technical and metaphorical have gradually made perspective one of the central phenomena of culture. I am profoundly conscious that there is much more to do; that this is effectively only an introduction. Yet, if it can truly introduce more critical and discerning minds to a vast realm of human activity, whereby we render things visible, the many invisible hours will not have been in vain.
I. ORIGINS

1. Introduction

There are a number of theories concerning the origins of perspective. From the sixteenth until the latter nineteenth centuries these were typically outlined in a cursory manner. This changed in the 1880’s when a new fascination for original sources made it important for the first time to confront the details of the methods and examine how they might have been reached. During the 1890’s philosophers of the neo-Kantian movement suggested that the activities of artists prefigured those of scientists, notably that artists working with perspective prefigured later developments in descriptive geometry. In art history, Panofsky made these assumptions a starting point for his studies. In psychology, and in the social sciences, there were other reasons for reflections concerning the origins of perspective. Marxism provoked a very intriguing set of possible causes. The history of printing has provided others.

In reconsidering the origins of perspective it is useful to distinguish between different stages and media involved. When we do so it is recognized that there are a number of origins that need to be explained. From the viewpoint of art history with respect to subject matter it is useful to examine developments in the history of narrative. With respect to the scientific laws of perspective it is necessary to look at a wider context of the history of optics than has been the case among historians of science by linking optics, mathematics and science. It is also important to recall that from the tenth century onwards the development of planispheric projection methods affected a whole range of scientific instruments and that the production of these instruments involved many of the individuals also responsible for the recuperation of ancient sources both via the Arabic and subsequently directly from the Greek. This led to new links between observation and representation. An understanding of this new interplay of technology and science, helps us to understand the emerging interdependence between instrumentation and representation inherent in perspective. Indeed it will be shown that the origins of perspective are integrally linked with a redefinition of knowledge that began in the latter thirteenth century.

2. Early Theories

During the early stages of major discoveries little attention is usually given to origins. Perspective is no exception. During the first half of the fifteenth century when Brunelleschi, Alberti and others were establishing its principles, nothing precise appears to have been written on its origins. A first mention occured in Filarete’s *Treatise on Architecture* (c.1464), who believed that Brunelleschi’s demonstration involved a mirror, but offered no clue why he began his studies. Manetti, in his *Life Of Brunelleschi* (c.1482-1489), implied that perspective arose from architectural interests but did not elaborate. Luca Pacioli, in his *Summa* (1494), mentioned the use of perspective in contemporary painting but was silent about the question of origins. The first half of the
sixteenth century brought no serious change. Pélerin (1505), Pacioli (1509), Ringelbergius (1535) in their treatises on perspective referred mainly to an artistic context but made no mention of Brunelleschi, Alberti or Filarete.

Vasari’s *Lives of the Artists* (1550) marked a significant change. He looked for the origins of perspective in painting practice of the thirteenth century. In his view, perspective arose as part of a general quest for naturalistic representation in art: “They sought to reproduce what they saw in Nature and no more, and thus they came to consider more closely and understand more fully. This encouraged them to make rules for perspective and get their foreshortening in the exact form of natural relief.”

Vasari noted the contributions of Giotto (1266-1377) with respect to foreshortening, while Giotto’s pupil, Stefano (1301-1350), “drew an edifice in perspective perfectly, in a style then little known, displaying improved form and more science.” Vasari cited the work of Domenico Bartoli and Jacopo della Quercia. He claimed that Paolo Uccello’s *Annunciation* was the first painting to use perspective, rather than Masaccio’s *Trinity* as is often claimed in the twentieth century. Vasari explicitly suggested links between the use of ground-plans and elevations in architecture and early methods of perspective developed by both Uccello and Brunelleschi. In addition, he noted connections with the measurement of ancient ruins, as well as with marquetry, scenography and implicitly with goldsmithing. A complete survey of Vasari’s comments on the early history of perspective is found in Appendix 5.

In the latter half of the fifteenth century, the origins of perspective became increasingly linked with mathematics. Piero della Francesca, in his *Perspective of Painting*, cited Euclid’s *Elements* and in his other two treatises, *On the Five Regular Solids* and *Book of the Abacus*, focussed on the construction of the regular solids, thus linking one of the major themes of the western mathematical tradition with perspective. His townsman (from Sansepolcro) and colleague, Luca Pacioli, developed this trend publishing the first treatise on perspective in his *Summa of Arithmetic, Geometry, Proportion and Proportionality* (1494) and by linking perspective explicitly with mathematical proportion in his *Divine Proportion* (1509). Dürer’s treatment of perspective in his *Instruction in Measurement* (1525) also took for granted this mathematical context.

In the second half of the sixteenth century, a small circle of scholars at Urbino explored the mathematical principles of perspective in greater detail. For instance, Commandino (1559), linked perspective with Euclidean geometry and related it directly to Ptolemy’s work on the planisphere in the context of astronomy. His student, Guidobaldo del Monte (1600) pursued this approach. In the Netherlands, Stevin (1604), reported how the Prince of Orange was dissatisfied by the haphazard ways in which painters arrived at their foreshortenings and wished instead “to design exactly the perspective of any given figure, with knowledge of the causes and its mathematical proof.” Paris and later London became the centres for this mathematical approach.

Meanwhile, authors of perspective treatises were becoming interested in the question. Although, Serlio (c.1540) specifically stated that he chose not to discuss the origins of perspective since Euclid had done so, he emphasized the reciprocal importance of perspective for architecture since: “no perspective workman can make any work without architecture, nor architecture without perspective.” Serlio also claimed that perspective
was synonymous with what Vitruvius called scenography, “that is the upright part and sides of any building or of any superficies or bodies”. Barbaro (1568) began his introduction noting that scenography was an important part of perspective; that Agatharchus had produced a tragic scene and written a first commentary on the topic; that perspective had been important among Roman scene painters and had become so again in the early Renaissance.

A combination of these artistic and mathematical traditions was carried out by Danti (1583) in his commentary on Vignola. Like Barbaro, Danti also referred to the ancient tradition of scene painting as a source of perspective, but added a more compelling incentive for its origins: “if the marvellous operations of nature and art drew men so much to admiration that they began to philosophize and investigate the causes thereof, they rightly exerted themselves greatly in searching the reasons for the effects which happen at the eye through the variety of the visual rays.”

Hence, claimed Danti, artificers had sought to find rules and instruments with which they could imitate visual effects and appearances and he was concerned: “with the most scientific who are not content in simply knowing how to operate well and knowing that a thing is thus, but in addition to know its causes. Hence I have endeavoured to demonstrate all the principal parts of this geometrically.” Danti aimed at reaching a larger group of readers than his contemporaries at Urbino but nonetheless cited various ancient sources: Aristotle, Euclid’s Optics as well as his Elements (in the editions by Peletarius and Clavius), Apollonius’ Conics, Archimedes, and Ptolemy’s Almagest. As a geographer, Danti drew on Ptolemy’s Geography. In optics his chief medieaval source was Witelo’s treatise. Danti also referred to most Renaissance authors on perspective from Alberti through to Stevin.

The seventeenth, eighteenth and nineteenth centuries continued these lines of discussion. Key individuals such as Lambert (1559) remained aware that the sources of perspective involved a whole range of fields including painting, architecture, scenography, optics and geometry. At the same time there was a trend towards two parallel schools. One assumed that the source of perspective lay in Euclidean geometry, and interestingly enough it was this school which first began consciously to write about the history of perspective: e.g. Montucla (1758) and Savérien (1766, see below p. 52*). In the nineteenth century this school saw the evolution of perspective as a first step in the direction of descriptive geometry (e.g. Gerhardt, 1877), a view that has continued through the twentieth century (e.g. Loria, Klein, Santillana). A second school looked for the sources of perspective in the history of art, relying on practical examples of painting as well as literary evidence concerning ancient scenography. A way to reconcile these schools emerged when a framework from philosophy was combined with a new approach to sources in art history.

3. Philosophy

While philosophers have been extremely interested in the philosophical implications of changing points of view (see below p. 118*), most have shown surprisingly little interest in the origins of perspective. Those who have touched upon the problem have often done so indirectly. Cassirer is a good example. In his Individual and the cosmos (1927, 1964), Cassirer focussed instead on the general problem of space (182):
One of the most important tasks of Renaissance philosophy was the creation, step by step, of the conditions for a new concept of space. The task was to replace aggregate space by system space. Space had to stripped of its objectivity, of its substantial nature, and had to be discovered as a free ideal complex of lines. The first step on this path consisted in establishing the general principle of the homogeneity of space.

In a footnote to this passage, Cassirer was content to cite Panofsky as evidence that perspective in the plastic arts was another manifestation of this phenomenon. For philosophers in the neo-Kantian tradition it was the origins of different kinds of space that was of central interest. In their view perspective was merely one of the practical consequences of this theoretical breakthrough.

There have been rare exceptions to this tradition. One was Graf Yorck von Wartenburg (1915) who, in his *Italian Diary* set out to explain the origins of perspective as a direct consequence of Christian transcendental ideas. Boehm (1969) analysed Yorck’s work and pursued this theme in terms of Nicholas of Cusa’s ideas. Gebser (1947-1965) explored the origins of perspective in the context of a highly speculative synthesis of world culture. Marxists (see below p. 11*) have been another exception. Saccaro Battisti (1980) drew attention to parallels between mathematical-geometrical structures and logico-ontological structures in mediaeval philosophy as premises for the development of perspective. Ströker (1958-1959) explored general phenomenological conditions for perspective (see below p. 129*). For the most part, however, the search for philosophical origins of perspective has proceeded second hand through art historians.

4. Art History

In the first half of the nineteenth century, Ranke had articulated the historian’s task as one of recreating events as they actually were (*wie es eigentlich geschehen*). In art history, this ideal, which brought a new attention to sources, achieved a programmatic direction when Eitelberger von Edelberg commenced his monumental series of *Sourcebooks of art history and art techniques of the Middle Ages and the Renaissance*. This brought Janitschek’s (1877) edition of Alberti, Ludwig’s (1882) edition of Leonardo and led to editions, most of them for the first time, of the other major fifteenth century treatises on perspective. Once art historians were confronted with the evidence of the texts (although these were not yet critical editions and gave little idea of all manuscript variants), the origins of perspective emerged in an entirely new light. One now had to explain the complexities of detailed verbal descriptions, which were open to more than one visual interpretation.

Meanwhile there had been developments on the philosophical front. Although Kant did not specifically discuss perspective he had emphasized space and time as a priori concepts. Hegel, Herder and Alexander von Humboldt pursued these ideas. Building on this tradition neo-Kantians in the late nineteenth century (e.g. Cohen 1889, 1912) claimed that there were direct connections between artistic work (*künstlerische Arbeit*) and scientific logic (*wissenschaftliche Logik*) and therefore viewed artists as researchers (*Künstler als Forscher*), as individuals who prepared the way for science. Cohen specifically cited the case of perspective: artists intuitively understood and drew spatial concepts before they were formalized. As we have just mentioned mathematicians held a
similar view. Hence art now became a prefiguration of developments in both mathematics and science.

The art historian, Panofsky (1914), took up these themes when he began his studies of Dürer. Renaissance art theory, he claimed, involved two major problems: accuracy (Richtigkeit) and beauty. Accuracy entailed a “geometrical-perspectival and empirical-scientific knowledge”. He considered the problem of accuracy in greater detail in Dürer’s Theory of Art (1915). Accuracy, he explained, required representing objects “as they are”, which varied according to the medium. In sculpture it entailed congruence of measured size. In painting it meant representing something equivalent to what is seen and this was precisely the problem of linear perspective. At this stage in his career Panofsky believed that one’s theory of representation depended on one’s theory of vision, and hence he searched for the origins of perspective in Euclid’s Optics.

When Panofsky entered the Warburg circle in Hamburg (1924) he also came into the neo-Kantian sphere of Ernst Cassirer. According to this view there were two fundamentally different approaches to science: one emphasizing substance (and definition) which dominated Antiquity; a second emphasizing function (and relation) which evolved during the Renaissance. In Antiquity the focus on substance was linked with concepts of sensuous space: i.e. unhomogeneous and anisotropic (see below p. 63*). In the Renaissance the concern with function entailed mathematical space: i.e. homogeneous and isotropic. Other historians of science (Cohn, 1896; Duhem, 1909; Olschki, 1924) referred to developments from Antiquity to the Renaissance in terms of a shift from a finite to an infinite world view. Art historians such as Riegl had postulated a parallel shift from depiction of isolated objects in Antiquity to objects in relation during the Renaissance. Panofsky produced a synthesis of these views. Hence he claimed that the Ancients had a finite world view which implied a notion of aggregate space (finite, unhomogeneous and anisotropic). By contrast, the Renaissance transformed this into an infinite world view with a concept of system space (infinite, homogeneous and isotropic). Corresponding to these were different methods of representation. Aggregate space led to a method of (visual-) angle perspective (Winkelperspektive). System space led to linear perspective. Now Panofsky claimed that one’s philosophical world view determined one’s concept of space, theory of vision and method of representation.

There were problems with this seductive explanation. For instance, Panofsky claimed that in Antiquity a type of curvilinear perspective, which he termed angle perspective, produced fish-bone perspective. Veltman (1986) demonstrated that this was not so; that Panofsky had misunderstood the projection system he was using. Moreover, if ancient concepts of a finite world were responsible for Euclid’s Optics and angle perspective, then Euclid’s Optics could not be the source of linear perspective as Panofsky had claimed earlier. Panofsky was aware that Renaissance authors of perspective treatises cited Euclid’s Optics; assumed that Euclid’s fundamental premises must have been revised and cited the 1557 edition by Pena as evidence thereof. Panofsky did not explain why the concept of infinity which arose in the thirteenth century, produced a change in the theory of representation by the 1420’s yet supposedly only changed the theory of vision in 1557. If changes in the abstract world of ideas governed innovations in vision and representation why was it that empirical examples of perspectival practice were in evidence a century before the advent of perspectival theory?
There were other difficulties. Panofsky implied that one world-view caused one corresponding theory of vision and one theory of representation. The artistic evidence suggests that there were at least four methods of representation in Antiquity which supposedly emerged from their one world view and one theory of vision: 1) optical adjustments methods which represented things higher up as larger in order that they would appear the same size; 2) so-called fish-bone or axial perspective; 3) inverted perspective and 4) those Pompeian examples which approximate effects of and some have associated with linear perspective. In the case of the Renaissance this proliferation of methods was even more dramatic. For, rather than being replaced, the methods used in Antiquity were continued and in addition there emerged new methods of linear, cylindrical, spherical, conical and pyramidal perspective. The proponents of linear perspective so often projected images onto curved vaults and ceilings that it even becomes difficult to claim that linear perspective was the dominant mode during this period.

Subsequent champions of Panofsky’s ideas did not remove these difficulties. For example, White (1949-1951, 1957) claimed that he accepted Panofsky, yet insisted that Pompeii showed evidence of linear perspective. If a given world view governs a particular method of representation then why should both a finite world view in Antiquity and an infinite world view in the Renaissance have produced linear perspective? White also claimed that the implications of Euclid’s *Optics* of Antiquity were the basis for Leonardo’s “synthetic perspective” during the Renaissance. Yet since this synthetic perspective was closely related to Panofsky’s angle perspective, why should a method associated with a finite world view in Antiquity have been developed in the context of an infinite world view during the Renaissance?

There were further problems with this approach to the origins of perspective. Panofsky relied on Cassirer’s framework, which assumed a basic dichotomy between finite and infinite and provided an elegant contrast between Antiquity and Renaissance. The dichotomy was questionable to begin with, for it could be argued that notions of vision and representation in Antiquity were too nebulous to identify a single theory, whereas in the Renaissance there were clearly alternative methods of representation, namely linear, cylindrical and spherical perspective and anamorphosis, such that one could not claim that one world view evoked one theory of vision and representation. Was one to assume, moreover, that there had been no developments since the fifteenth century? If this still seemed feasible in the 1920’s, it was no longer possible in the 1990’s with advanced quantum physics, fractals and catastrophe theory.

Panofsky’s attempt to find the origins of perspective in philosophy and metaphysics may excite more general attention than precise reflection, but it has helped more than any other text to make questions of origins of perspective important in the twentieth century. The answers offered have ranged from incidental remarks to complex theses. Since many are repetitive it will suffice to mention only some of the key examples. Kallab (1900) argued that Christian symbols as they developed in the later mediaeval period required perspective to a certain amount. This idea was taken up by Kern (1912) who searched for the origins of perspective prior to Brunelleschi in the painting practice of Lorenzetti and suggested links with Ptolemy’s *Geography*. Later Kern (1938) also suggested that the origins of perspective lay in mathematics and optics, both classical (Euclid) and

Argan (193), in an influential article, explored the idea that perspective had its origins in a new concept of space in architecture with Brunelleschi. Francastel (1951) used this as a starting point for one of the most eloquent interpretations of Renaissance perspective. He claimed that Brunelleschi introduced a “new aesthetic conception of space....space ceased to be the cube of air that a vault covers; it possesses an homogenous quality and is found everywhere. it is at once container and contained; it envelops and is enveloped.”

Francastel insisted that Renaissance perspective had enormous consequences after noting that it was a:

fundamental discovery, which concerns the particular qualities of light - an invisible substance, but susceptible to let itself be measured and manipulated by the artist, inspired not only the idea of a new architectonic functionalism but also a new system of pictorial space to be elaborated. Brunelleschi is the man who substituted the plastic evidence of the Middle Ages founded in stereotomy, the size and assemblage of blocks and the manipulation of enclosed light, the necessity of another compartmentalization of space, in a system which reproduces a sort of imaginary model but which allows all the regions of space to communicate amongst themselves....

It is not only a new architecture and a new [style of] painting that resulted, but a new society and almost, materially speaking, a new world. The integration of concrete and subtle parts of the physical universe, the faith in the magic of number, prepared the discovery of America, and the new jurisprudence founded on the equilibrium of the States.

Exactly how all this followed was not explained. Instead, Francastel offered his own provocative survey of the history of perspective from the fourteenth to the twentieth centuries (see below p. 52*). In his concluding section he cited the ideas of Levi-Strauss and insisted that “Scientifically there is no doubt that the art of an époque is greater than the literary expression of a society: it is founded on the most profound mental and physiological structures of man. It is not a superstructure, but a language”.

Francastel developed this analogy of language and art in his Figure and place. (1967) and suggested that seeing was deciphering.

Boskovits (1962), claimed that the origins of perspective lay neither in vision nor in geometry, but rather in the auxiliary sciences of mediaeval architecture, in workshop traditions; in problems concerning the correct representation of architectural proportions; that perspective involved the geometrical representation of proportions which link one object with another. Hence Ghiberti had insisted that measures were inherent in nature and hence symmetry, proportion, proportionality and commensuration were all linked with the early development of perspective in the Renaissance.

Garin (1954), turned to the scientific and cultural atmosphere in his search for origins and argued that Leonardo’s interests in optics were more important than his interests in geometry. In the next decade it became the fashion to see optics as a key to the origins of
perspective. Parronchi (1964), focussed attention on mediaeval authors, notably Alhazen, Witelo, Bacon, Peckham and Blasius of Parma. Edgerton (1967), also claimed that mediaeval optics was the main source for Renaissance perspective. Dalai (1968), cited both Sanpaolesi’s attention to physiological optics and Parronchi’s twin focus on mediaeval optics and mathematics (e.g. Leonardo Pisano). Dalai also suggested that there were two lines of development: one which had come via Brunelleschi, was based on concerns with reflection and which, though it involved architectural practice and Ptolemaic geography, was concerned primarily with laws of mirrors. A second line of development, based largely on mediaeval sources advanced via Ghiberti and Uccello. Battisti (1971), stressed that Florence was not the only centre to be considered; the Flemish school of Van Eyck had played an important early role, as had other Italian cities including Milan, Padua and Rome. Edgerton (1978), offered an important summary of alternative explanations for origins, suggesting that there were no less than four traditions to be considered: optics, geometry, geography and metaphysical theology. Veltman (1980) noted that in terms of perspective, Ptolemy’s work in astronomy, namely his treatise on the *Planisphere*, was probably more important than his work on geography, an idea which has been pursued by Aiken (1986) and Sinisgalli (1993).

Fernande Saint-Martin, in *The Topological Foundations of Painting* (1980), devoted a chapter to Euclidean space. She claimed that perspective was very much an occidental phenomenon which had (119): "established an essential break in human sensibility such as it was expressed in the pre-history of nearly all other cultures". She acknowledged that many saw it as the ultimate product of sensibility and rationality and that it was an attempt to deal with problems of depth, of foreground and background. She cited the ideas of Gleizes and Metzinger that the space of painters would preferably be Riemannian rather than Euclidean and called for a wider definition of the term (124): “By the term perspective, rather, one should understand every global system which defines the modes of interrelations among the collections of elements, in accordance with certain a-priori co-ordinates.” The term Euclidean perspective, claimed Saint Martin, was misleading because it was not based directly on Euclid. Rather, perspective as it developed in the Renaissance, had only been possible as (127): “a result of a sort of transubstantiation of the sensible intuitions subjected to the elements furnished by Euclid, stripping them of their finite and concrete character to permit them to integrate themselves in much more abstract systems of interrelations.”

Saint-Martin cited Doesschate (1964) to note that there was no clear evidence that Alberti or Piero were familiar with Euclid's geometry and followed Edgerton's (1975) claim that it was spatial co-ordinates of Ptolemy's cartography that provided (128) " the fundamental elements in the spatial infra-structure of the Renaissance". The resulting space corresponded neither to the experience of the senses nor to the findings of science concerning the nature of reality. Hence (129) “homogeneous space is never a given; it is a space engendered by a construction". According to Saint-Martin (132), it was Alberti who introduced the vanishing point although, she claimed, it was not until Leonardo that a majority of fifteenth century artists began adopting perspective. In contrast to some historians who have seen the rise of perspective mainly in positive terms, Saint-Martin was convinced that perspective imposed new limitations on western culture (134):

Euclidean perspective imposes a particular hierarchy of emotive experience where the projection of the me in the foreground, the mass, the vivid colouring is at once negated by its insertion into an abstract system where the distant imposes itself as the limit, the end, the point where the co-ordinates of particular
experiences join. This forced equilibration always remains an artificial model of the experience of the me and the non-me, because it tends to deny the expressive validity of the near which will inevitably only constitute a stage in a passage towards the far. It also denies the distant itself, by the impossibility of affirming it by pictorial means themselves, which shrink it to render it nearly imperceptible, which hide it in zones of shade or confused atmospheric pockets, or alternatively bathe it in a diffuse luminosity. Inside this fixed schema, with irremovable boundaries our civilization would like to confine the representations that a person can give of their experience -of me -in the world. It is certain that the survival of artistic activity is linked since the last century with a continuous battle more or less overt but definitive nonetheless, not just against the primacy of the figurative image but in a more essential way in favour of a resourcing, a peremptory reaffirmation of pre-Euclidean spatial experiences at the level of primary forms and topological relations.11

Johannsen and Marcussen (1981), in an important article, explored the role of several disciplines in explaining the origins of perspective: optics, measuring (including surveying) and statics, geography and astronomy as well as the cultural background of early fiftieth century Florence. Five conditions necessary for the construction of perspective were identified: 1) use of a visual pyramid as a geometrical model of the visual process; 2) a plane corresponding to the picture plane; 3) proportionality between the size of an object and its dimensions on the picture plane; 4) a graphic representation; 5) projection methods. Veltman (1986) focussed on the third of these problems, the question of plane thinking, and suggested at least five traditions which helped in this development: geometry, astronomy, architecture, surveying and optics and has since claimed (1992) that all of the above mentioned traditions played some role. Meanwhile Andrews (1988) and Veltman (1992) have emphasized the importance of narrative for the development of pictorial perspective.

Simon (French, 1988; German, 1991), in a book that focussed on the optical theories of Euclid and Ptolemy, examined the possible consequences thereof for representation. Following the view of Panofsky, Simon (1991, 79) suggested that the fourth postulate of Euclid’s Optics entailed curvilinear rather than linear perspective. Consequently, he claimed, Renaissance theoreticians were torn between two conceptions of perspective, an artificial (künstlichen), plane one for painterly representation and a natural, angle based one for optics. He went on to suggest that (79-80): “the still limited character of their trigonometry” might help account for “the lack of rigour in the perspectival drawing of the Ancients.”12 According to Simon (84): “The analysis of visual perception was doubtless not yet sufficiently advanced in order to be able to distinguish clearly between the description of natural vision and the experiences of perspectival representation.”13

Salvemini (1990) offered new criticisms of Panofsky, claiming (60) that his method was a transposition of ideas of pure visibility of the late nineteenth and early twentieth centuries to the past, that was not supported by historical evidence. His method of iconographical analysis was wrong because it (62): "constantly reduces to a schema all that which is not demonstrable extensively through the lack of concrete sources."14 Salvemini claimed that the inverse size/distance rule was known to Levi ben Gerson, and used this as a starting point for another attack on Panofsky's method (73):
Propositions are demonstrative, they assume the form of a question (quaestio), which is the literary form of the mathematical theorem in which the concepts are not logistic as in contemporary theories of physics. This measure of distance will therefore be neither fixed, nor arbitrary, nor casual nor objective, nor subjective but rather an independent variable. To recognize this general rule in itself does not mathematicize empirical space any more than the perpendicularity of the optical axis geometricizes the visual image.

Elsewhere Salvemini lamented (97) "the material impossibility of establishing a typological model for perspective studies."

Kemp (1990), offered three principal reasons for the origins of perspective: a) that the systematic recording of visual phenomena should be seen as a worthwhile goal; b) that the invention should be attainable in terms of the necessary levels of understanding and skill and c) historical factors ranging from the most general aspects of what may be called the world view to the specific circumstances (intellectual and social) of the individual or individuals involved. Kemp noted his intuition (335):

Edgerton (1991), returned to these questions of the origins of perspective in The heritage of Giotto’s geometry. Edgerton drew attention to a series of unpublished lectures by F. Cranz (1984) in which he had characterized the re-orientation of the twelfth century as a shift from conjunctive to disjunctive thought: i.e. from an assumption that one was a part of everything that one considered to an awareness that what one sees in one’s mind differs from things in the external world. According to Cranz, Anselm and Abelard had played an important role in leading philosophers to understand themselves (40): “as detached from nature, as outside observers limited by the inadequacy of their mental formae and describing phenomena only metaphorically”. Edgerton suggested that the recovery of ancient texts of geometry would have (41) “complemented this increasing twelfth century predilection for disjoining the forms in the mind from the forms in the external world”. Edgerton focussed on the importance of Bacon’s views citing in particular a passage from his Optics that stressed the importance of visualization using figures (88):

For without doubt the whole truth of things in the world lies in the literal sense, and especially of things relating to geometry, because we can understand nothing fully unless it is presented before our eyes in figures, and therefore in the scripture of God the whole knowledge of things to be made more certain by
geometric figuring is contained and far better than mere philosophy could understand it.

In his book Edgerton outlined the geometrization of pictorial space, supernatural space, terrestrial space, heavenly and astronomical space, emphasizing the importance of sixteenth century printed books in the spread of these principles. With respect to the actual origins Edgerton claimed that there were two serious interpretations, one claiming (89):

that Brunelleschi’s two lost pictures were but the latest examples in the gradual evolution of Western art toward realism, incremented by some sort of application of traditional architectural or surveyor’s projection.....The second opinion - more revolutionary in the sense of a classical revival- holds that Brunelleschi was inspired less by architectural and surveying technique than by the ancient science of optics....Brunelleschi seems to have exploited an optical theory never applied to painting before, that the implied eye level of the artist/observer must determine the centric point on the picture surface and therefore the horizon within its fictive depth.

Edgerton did not discuss the possibility that Renaissance optics had in fact integrated essential aspects of the surveying tradition (cf. Sources, p. 142-154*). He returned to his earlier (1975) claims that a third method of cartographical projection attributed to Ptolemy had also played an important role in what he claimed to be the re-discovery of perspective. Notwithstanding, these points on which we disagree, Edgerton’s book is an important attack on fashions in critical theory and methodology that reduced perspective and chiaroscuro as (4):

artificial systems within a linguistic-like sign system expressing the peculiar values of western civilization. Radical supporters of this latest relativism (“multiculturalists” as they like to call themselves) argue that during the Renaissance, upper-class patrons championed linear perspective because it affirmed their exclusive political power. Single viewpoint perspective after all, encourages the “male gaze”, thus voyeurism and the denigration of women, police-state surveillance and imperialist “marginalizing of the other”.

Edgerton very clearly and elegantly established that although it had its origins in Europe, the consequences of perspective were international and should not be associated in terms of any particular gender, class or other interest group. Hence while acknowledging the claims of those who sought to dismiss perspective as a convention (Bryson, Goodman, Mitchell) he sided firmly with those who insisted on its objective dimensions (Pirenne, Gombrich, Kubovy).

5. Psychology

Despite their individual differences, the authors considered thus far were agreed that the development of perspective was somehow to be understood in terms of perception. A quite different approach was taken by Gablik (1975) who set out “to emphasize the logical rather than the perceptual character of art”17 and explicitly took issue with the perceptual theories of Arnheim (1966 etc.) and the Gestalt school. Arnheim’s claim that “eyesight is insight”18 could not, she claimed, explain how modern art had liberated itself
from “figurative or representative elements.”

Gablik wanted “an epistemological model of art history which is based on cognitive theory, rather than on a neurophysiological model of perception.”

Inspired by the developmental concepts of Jean Piaget, Gablik returned to ontogenetic-phylogenetic analogies, which had been popular in the nineteenth century (cf. below p.142-144**) involving comparisons between stages of development in an individual person and developmental stages in culture as a whole. However, she was careful to insist that culture does not simply recapitulate development in children. There were parallels.

Piaget had identified five stages in the development of a child (see below fig. 57 and p. 139*). Gablik was able to reduce these to three essential stages. First, there was a pre-operational stage (eighteen months to four years in the child), involving topological relations of space, an enactive mode of painting, and corresponding to ancient and mediaeval art in terms of cultural development. Second, there was a concrete-operational stage (six to fourteen years in the child), involving projective and Euclidean relations of space, and an iconic mode of painting, corresponding to the Renaissance in terms of cultural development. In this model, linear perspective was characterized by the static viewpoint of a single observer and separation of observer and the world. Third and finally, there was a formal-operational stage (above fourteen years in a child) involving indeterminate, atmospheric space, a symbolic mode of painting, and corresponding to modern art in terms of cultural development. In Gablik’s view (12,31):

These stages in the development of art correspond to learning processes and to transformations in concepts of self and society (fundamental transformations, that is from one picture of the world to another). I wish to assert that it is the transformational element in thinking that is actually the source of art’s development. It has led pictorial imagery on the one hand toward greater mobility; on the other, it has brought about a complete independence from figurative or representational elements.

Gablik served as a point of departure for a more serious treatment of these problems by Blatt and Blatt (1984). According to their view the tradition of Kant and neo-Kantians such as Cassirer had led to structuralism which attempts to (39): “define principles and cognitive structures that underly all human intellectual endeavors....This search for the underlying, unverbalized (unconscious) order in cognitive endeavors is a quest for the identification of the basic constructs through which individuals understand and organize their universe”. The Blatts cited evidence from a whole range of disciplines, to claim that such cognitive schemata had been used to understand neurological processes, memory, perception, information processing, linguistics, social order, structural anthropology, psychoanalysis and the development of children. They related this quest for structure to the search in art history for a (39) “vocabulary of form”, “a matrix or scale of structured relationships” and a larger quest to discover (40) “basic relationships of form and their processes of transformation”, which they termed mental constructions, “cognitive schemata, patterns or gestalts”. They claimed that these conceptual explanations had replaced traditional perceptual explanations.

Gablik had specifically challenged the perceptual views of Arnheim and the Gestalt school. By contrast, the Blatts accepted the Gestalt school as yet another example of a
quest for structure which had been making serious strides since the time of Kant. Historically, Kant himself had been very much concerned with the ways in which knowledge acquired through our senses affected our ideas. The Blatts did not mention this. Historically, there had been notable differences in the approaches of Kant and Hegel in this regard. Hegel was not mentioned in the Blatts’ account. Historically, there had been major differences in approaches to knowledge which psychologists have classed as a struggle between nativism and empiricism (see below pp. 60-61* and fig. 10). The Blatts’ account gave the impression that nativism was the only valid school.

In terms of art history, the Blatts used Piaget as a starting point. Piaget’s sensorimotor and pre-operational levels were used to cover paleolithic and Egyptian art. Piaget’s intuitive level was renamed an intuitive (perceptual) level, linked with projective-Euclidean concepts of space and used to explain the time span from Greco-Roman art through to the early Renaissance. Piaget’s concrete operational level was linked with further developments in projective-Euclidean concepts of space, with the period from the late Renaissance to Impressionism, with the Copernican and Newtonian world views and with Stevens’ concept of interval scale. Various steps of each stage were carefully identified (e.g. fig. 1).

<table>
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<tr>
<th>Concepts of Space</th>
<th>Concept of the Object</th>
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<td>Projective Euclidean Concepts of Space</td>
<td>II Intuitive (Perceptual) Level</td>
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<td>objects into</td>
<td>1. Beginning integration of pairs or small sets of</td>
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<td>object and</td>
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<td>configuration.</td>
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<td>configuration.</td>
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<td>1. Space as defined by the straight line and</td>
<td>3. Perceptual totality of concrete, literal</td>
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<td>projective-sectional planes.</td>
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<td>2. Relationships between objects defined in</td>
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<td>relative terms based upon apparent size and distance in space.</td>
<td>4. Intuitive (empirical) sense of perspective</td>
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<td>3. Several interrelated objects in a qualitative</td>
<td>which transcends specific context.</td>
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<td>organization of three-dimensional space.</td>
<td>5. Schemata based on total, fixed, constant,</td>
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<td>4. Differentiation among various alternative</td>
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<td>viewpoints.</td>
<td>6. Some relations of manifest, concrete, part</td>
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<td>properties within total object.</td>
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<td>the support of concomitant topological cues.</td>
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<td>6. Geometric coordination of</td>
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<td>operations with transformation, reversibility</td>
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<td>and conservation.</td>
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III Concrete Operational Level

1. Transformations, reversibility and
three-dimensional space

7. Measurement in three dimensional space by means of a coordinate system within total object (part/whole) system.
   a) Linear perspective in symmetrical pyramidal structure
   b) Linear perspective in asymmetrical diagonal structure

8. Space as homogenous container, as stable, coordinated structure and potential positions and movements in a coordinated, quantitative spatial system.

9. Conservation of distance, angles and parallels, reciprocity, symmetry of perspective, proportionality.

10. Multiple perspectives.

Fig. 1. Parallels between concepts of space, object, and scale, periods in art history and cosmological world view from the time of the Greeks to Impressionism according to Blatt and Blatt (1984).

Such schemata which appear to explain the key developments of man’s intellectual and cultural development since the beginning of time in four pages of charts are very seductive. Unfortunately they explain less than they seem. If art from the Greco-Roman period, the Middle Ages and the Early Renaissance belong to the same stage of development how does one account for the rather remarkable differences in style between these periods? Are nearly one thousand years of mediaeval art simply to be explained away as equivalent to a slight regression or progression in the growth of a child? If we accept parallels between cultural growth and child development as true, we are accepting that the greatest achievements of Antiquity correspond to the activities of children between the ages of six and nine and similarly that the heights reached by Leonardo, Raphael and Michelangelo in Renaissance art correspond to the development of persons under the age of twelve. Indeed this view reduces the whole of human culture rather dramatically to various stages of puerile (or puellile) activity.

There are further problems. Piaget’s claims were based on experiments with Swiss children in the 1940’s, and as subsequent critics have pointed out, these were mainly male children. An obvious question arises: would the spatial abilities of Swiss girls at the
time have been the same? More fundamental for our purposes is to ask why this particular sample in a particular place and time should be a model for the whole of history? A child living in Egypt in the eighteenth century B.C. before the discovery of perspective would obviously have reached neither projective-Euclidean concepts of space nor a concrete operational level of objects by the age of eleven nor at any point in their lives. Nor would Renaissance children have mastered Riemannian space at the age of twelve or during their lifetimes.

Hence there is no necessary connection between concepts of space or of an object and a given age of a child. A child growing up in the 1990’s in one of the technologically advanced countries might well have a sense of perspectival space and a more advanced concept of an object at an earlier age. This in turn has deeper implications. Contemporary theories about conceptual development cannot simply be imposed on art in other places and at different periods of history without ignoring their own stated goals. During the Renaissance both artists and art critics insisted that they were concerned with recording the world of nature as seen by their eyes or as Vasari put it “to reproduce what they saw in Nature and no more”. If some artists today have conceptual goals of art, this does not mean that these contemporary conceptual aims encompass the aims of earlier cultures. Paradoxically, while calling for a developmental model, the Blatts use a framework statically based on the assumptions of their particular time and space

6. Social Sciences

This danger of philosophical systems which offer handy frameworks at the expense of ignoring the complexity of historical records is also witnessed in the social sciences. Damisch (1979) produced an essay on the origin of perspective in which he focussed on Brunelleschi’s demonstrations, linked these with the traditions of geometry, optics and painting, and suggested that the philosophical implications of their approach to measurement went beyond all of these disciplines. This served as the starting point for the longest book devoted explicitly to the origins of perspective (1987, English 1993) which was so subtle that it eludes clear description. The arguments focussed on Brunelleschi’s two demonstrations and on the three panels of ideal cities now in Baltimore, Berlin and Urbino. Damisch mentioned links between painting and architecture, dwelled on the importance of scenography and emphasized the context of geometry.

While some scholars have gone to considerable pains to distinguish clearly between the rules of grammar applicable to verbal language and other rules in visual language (cf. Saint-Martin, Sonesson), there has been a trend in Russian authors to conflate analogies between language and painting (e.g. Uspensky, see below pp. 51-52*). Damisch followed this Russian structuralist tradition, drawing on analogies of Jakobson (386) “between the role of grammar in poetry and the rules of composition founded in the art of painting on a geometrical order either latent or manifest.” Damisch discussed painting in terms of reading, not just a process of describing in the sense of Alpers, but rather as something demonstrative which creates a system. Like the neo-Kantians, he suggested that this system did not derive from geometry but rather prefigured its later developments. Like Husserl, he was interested in the metaphysical or at least the meta-logical implications of
these spatial developments. Like the structuralists he continually referred to grammar, but ultimately assumed a combination of geometry and language (406):

In the historical context where we are placed, artificial perspective furnished painting with a formal apparatus such as that of enunciation can be, with which it presents numerous common traits. To begin with the distribution which it organizes of points of view, vanishing points and distance points, and (the corollary thereof), that of the here, the there and the over-there, which allows one to speak, not yet in a metaphorical sense, of a geometry of enunciation which would have its analogue in the figurative register....The enunciation cannot be assigned simply to the network of pronouns and indices of position in time and space. The formal apparatus which puts in place the perspectival paradigm is the equivalent to that of enunciation to the extent that it confers a sense to its direction at the same time that it opens the possibility of something like an enunciation in painting. As Wittgenstein writes, the word is nothing other than a point, the proposition is a vector endowed with a sense, that is too say with a direction.  

Damisch did not explain precisely what were the roots of this so-called direction giving geometrical enunciation that is perspective. He suggested repeatedly that it emerged out of Brunelleschi’s panels which were simultaneously models and demonstrations, without revealing why Brunelleschi made them or why Lorenzetti should not have made them. As with Gablik and the Blatts there was an a-historical trend in Damisch’s work. On the surface his work was a close reading of two experiments by Brunelleschi. But these were experiments of which the original apparatus was apparently lost by the mid-fifteenth century, else Filarete and Brunelleschi’s biographer, Manetti, could have described it precisely. Damisch used hundreds of pages to describe experiments which were described second hand in six lines, with very little mention of dozens of articles which have already been written on this topic (see Brunelleschi in Appendix 3).

7. Marxism

Karl Marx, in his writings, had little to say either about the origins of perspective or about its effects. However, in the German Ideology (1970), Marx made an analogy between life in an images in a camera obscura:

If in all ideology men and their circumstances appear upside down as in a camera obscura, this phenomenon arises just as much from their historical life processes as the inversion of objects on the retina does from their physical life processes.

In itself this phrase is not particularly dramatic, but it is symptomatic of a branch of Marxist rhetoric which uses a scientific phenomenon as its starting point, interprets it metaphorically, usually socially, such that it completely loses its scientific truth, yet by association with the scientific principle from which it departed takes on an air that is more serious than it deserves. In the hands of enthusiastic commentators this particular sentence has become seen as serious evidence for undermining a one-to-one correspondence between original objects and their images, and has come to play a role in a trend towards anti-ocularism (cf. below p. 215*). A physical phenomenon treated
metaphorically has become a starting point for claims about social realities. Debord (1967) extended this approach from a particular image to the concept of spectacle, now denying the physical to emphasize the social: “The spectacle ‘is not a collection of images but a social relation among people, mediated by images. It is the material objectification of alienated socioeconomic relations, the “true reflection of the production of things and the false objectification of the producers.”

Abels (1982), drawing on ideas of Marx and Holzkamp (1976), considered a developmental approach in which perception and representation became functions of class levels and other societal structures. Goldstein (1988) presented a thorough Marxist analysis which offered the most daring explanation thus far for the origins of perspective. Goldstein began with a critique of Panofsky, Cassirer and Edgerton before arguing (25):

that the relationship between linear perspective and the new cosmology of the renaissance is one of parallelity since both are different representations of an emerging social structure, namely, modern capitalism. Further, the various cultural activities, such as music, drama, prosody and the like are representations of the new production relations; they are parallel precisely because they are representations of one and the same social base.

Goldstein was concerned with three aspects of linear perspective: first, that space is quantifiable and homogeneous. In his view this was a result of divided labour production because it transformed traditional artisan labor (63):

into unskilled, undifferentiated, homogenized labor. When labor becomes homogenized in fact, it becomes homogenized in concept: it becomes labor as such. The cost of such labor can now be calculated and expressed in terms of expenditure of energy and duration of time....Labor thus becomes quantified....The attitude of calculation spreads as an indispensable part of the new mode of production to all areas of culture, science included.

This was restated more forcefully when he claimed that the source of quantification lay (73): “in the experience of divided-labor production whereby unskilled labor can and indeed must be regarded as labor as such, homogenized and then divided into time units which can then be multiplied by the rate of reproduction of the worker which is set at subsistence level, which is itself a mathematical calculation”.

One problem with this explanation as he himself admitted (73) “is that it places divided-labor production earlier than any empirical evidence would appear to justify”. This question of periodization became the more acute when he turned to what are supposedly corresponding developments in other branches of culture, notably (109) polyphony in music (c.900-1050) and in prosody (110) “the development from alliterative form to accentual-syllabic in the period between the ninth and the thirteenth centuries.” If there is a unity of cultural expressions as he claimed then why did perspective not emerge in Carolingian times rather than the Renaissance? And what evidence is there of divided-labor production at the time of Charlemagne? None.

There were further problems. Goldstein assumed that this new phase entailed a loss of artisanal skills and the rise of unskilled labor. Why then was it precisely in the Renaissance that there was a dramatic development of books on specific trades of which
the *Book of Trades* (*Ständebuch*) of Jost Amman was the most famous? Or why should Vasari, who was the first to document the rise of perspective, take such pains to emphasize the particular professions and trades of those responsible, be they painters, sculptors, architects, or goldsmiths? Indeed was there not serious evidence that the Renaissance saw a new self-consciousness in this tradition of skilled artisans and was it not they, rather than their anonymous unskilled counterparts, who were responsible for the great achievements of pictorial and architectonic space? How else are we to explain that so many Renaissance masterpieces were produced by well known, well trained artisans? What happened to the supposedly revolutionary achievements of the anonymous unskilled?

The second aspect which interested Goldstein was that physical space is continuous, isotropic, material, three-dimensional and infinite. Here he drew on Marx’s concepts of alienation (*Entäußerung*) and estrangement (*Entfremdung*) to claim that (35-36):

> the objectification of nature takes place not because labor is alienated in the product, but because under conditions of private property the product is estranged from the producer: the product becomes a commodity....Under conditions of estrangement as it occurs in commodity production, the human being regards nature as an object, distanced and opposed to him, so that space is conceived not as a closed system of which nature is a part, such as we find it in organic conceptions of nature, but as a void within which objects move and which extends in all directions without end. It is a three dimensional infinite world; it is at the same time a mechanistic world.

In developing these ideas Goldstein also drew on the views of Ruben (74):

> The concept of infinity develops as part of a process in which the organic community dissolves and the emphasis is placed on the individual. What is lost in this process is the well defined place of the individual in feudal society as against the indefinite place of the active property owner. It is the transition from immovable property in land to the moveable property (i.e. money itself, tools, commodities, etc.) that generates the new conceptions of time and space. With respect to space, since the individual as property owner has greater potential for movement, his sense of his own movement changes. He conceptualizes his activity as the free movement of a body in absolute space (and time).

Goldstein reformulated this idea in his own terms (147):

> Divided labor is labor coordinated around a machine, so that interdependence in the production of goods is visualized as spatiality. The living experience of coordinated undifferentiated labor centered around a machine is visualized as geometrized space in the form of a three-dimensional drawing or a new cosmology, geometrized physical space within which bodies move subject to constant universal natural forces, so that their motions and relationships can be expressed mathematically in equations. In perspective drawing objects diminish in size in proportion to their distance from the viewer: the view is that of a quantifying, geometrizing, mechanizing mentality which is specific to capitalism.
Here again there were problems. Goldstein claimed that the separation or estrangement of worker from the products of his work caused the distance necessary for a new concept of space. Yet the painters who produced the early works of perspective were precisely those who were not estranged from their work. Artists such as Brunelleschi, Ghiberti and Uccello received commissions and were rewarded for their efforts. Ruben’s assumption that community needed to dissolve for individuals to emerge, was equally misleading. Were not many of the key artists in the Renaissance members of guilds and very much members of their local communities? The notion that mobility generated a concept of space is intriguing. It is true that Brunelleschi went from Florence to Rome and that the author of the first printed French book, Jean Pélerin, was called the pilgrim (le Viateur). But why then were the earliest spatial paintings not done by ancient soldiers or mediaeval pilgrims? Money is spoken of as one of the universalizing elements. This is only partly true since each major town in the Renaissance usually had its own currency as well as its own measures. Whence equivalences through money were by no means as universal then as they are today in a world where credit cards offer a standard.

A third aspect which interested Goldstein was that perspectival pictures depend on vision of a single pair of eyes viewed from a fixed position. Here he claimed that the rise of individualism, particularly the individual entrepreneur of capitalism, was the source of one-point linear perspective. As he put it (83):

The painting rendered in terms of linear perspective is no less an expression of the bourgeois individual. In such a picture the view presented is, as we have seen, that of a particular pair of eyes, in a particular position, and at a particular time, so that nothing is seen but what the viewer can rationally see. It is the high valuation set on the here and the now that finds expression, the practical realism of the bourgeois-rational, ahistorical and hence, static.

In itself Goldstein’s association of the capitalist’s viewpoint and one-point perspective is attractive, but becomes confusing in the context of his other arguments. For he also claimed that the concept of homogeneous space necessary for perspective was created by the estrangement of unskilled workers. If the victims of capitalism had this new insight why was it not they who produced the consequences rather than their exploiting entrepreneurial capitalist employers? If the employers could get these insights without their employees, why then should one emphasize a move towards unskilled production? Indeed if unskilled production was so important in this context, why then was the development of perspective linked with the rise of artists’ guilds, academies and eventually schools of drawing? Suppose we accept that both sides of Goldstein’s arguments are important, namely, employers and employees. Why then do Brunelleschi’s first two examples reflect neither a capitalist viewpoint nor unskilled workmanship? Moreover, why are most of the early examples of perspective in an ecclesiastical context and linked with sacred narrative rather than reflecting the new modes of production which were presumably the source of their inspiration?

Notwithstanding the logical and other contradictions in Goldstein’s approach, subsequent commentators such as Jay (1994) have cited his work as if it were authoritative. Jay, whose work is discussed at length below (p. 215*), related these claims (59) to Williams’ (1973) contention that “only the exaggerated capitalist separation of the spaces of
production and consumption permitted a radical disjunction between the working the land and merely viewing it from afar as an aesthetically ‘pleasing prospect’, which was the real estate form of perspectival art.” The problem with this reasoning is that a separation of landowner and worker was well established in Egyptian times and continued throughout the Middle Ages. Witness, for instance, the Duc de Berry and his *Very rich hours* (*Très riches heures*), who must have been very conscious of this distinction in the fourteenth century, even before linear perspective in its technical sense had been discovered. Jay went on to surmise that (59): “The placement of objects in a relational visual field, objects with no intrinsic value of their own outside those relations, may be said to have paralleled the fungibility of exchange value under capitalism”, without offering any serious evidence by way of proof.

If one looks back at these explanations as a whole, some interesting patterns emerge. At the outset those who discovered perspective were unconcerned about its origins. Approximately 130 years afterwards authors such as Vasari sought answers in practical terms mainly with reference to professions such as painting and architecture. In the late eighteenth and early nineteenth centuries the philosophical systems of Kant and Hegel prepared the way for interest in a theoretical framework; a trend which was taken up in the early twentieth century by the neo-Kantians, Cassirer and Panofsky. The basic assumption of this school, that a given world view determined one theory of vision and one theory of representation, has since been shown to be simplistic. Antiquity saw the rise of several approximate methods. The Renaissance saw the development of a whole series of methods. According to Barbaro (1568) and Danti (1583) these were also often approximate although, in the course of the sixteenth century, they became mathematically precise. So the shift was not from one method in Antiquity to another in the Renaissance but rather from vague connections between theories of vision and representation to a conviction that these relations could be precisely defined and mathematically demonstrated. In this development the use of instruments played a much greater role (see below p.102*ff.*) than assumed by either the neo-Kantians or the Marxists, pace their materialist explanations. Underlying this was a more fundamental problem. The search to explain the origins of perspective in terms of a world view was anachronistic, because the universality of concepts and methods that we associate with a kind of world view did not emerge until the twentieth century.

8. History of Printing

One of the important claims concerning printing and perspective was made by William Ivins, in *Prints and Visual Communication* (1953). Ivins considered three basic events of the fifteenth century: the pervasion of ways of making printed pictures, the development of perspective and doctrines of the relativity of knowledge. He pointed out that the topics (24): “were and still are superficially so unrelated that they are rarely thought of seriously in conjunction with one another. They have revolutionized both the descriptive sciences and the mathematics on which the science of physics rests.... Their effects on art have been very marked”.

Ivins served as a starting point for Marshall McLuhan’s more dramatic claims in the *Gutenberg Galaxy* (1962, 56): “primitive drawing is two dimensional, whereas the drawing and painting of literate man tends towards perspective”. McLuhan remained
unclear concerning the precise relationship between perspective and printing. On the one hand, he argued that (138): “the sheer increase in the quantity of information movement favoured the visual organization of knowledge and the rise of perspective even before typography”. On the other hand, he suggested that typography was actually a prerequisite for perspective (138): “As the literal or the letter became identified with light on rather than light through the text there was also the equivalent stress on point of view on the fixed position of the reader: “from where I am sitting”....This uniformity and repeatability of typography...is the necessary preliminary to unified or pictorial space perspective “.

These connections became part of a larger set of basic oppositions that guided his work. There was, he claimed, a basic distinction between the tactile and the visual27; between acoustic space and visual space28; or between the audile/tactile and the visual29. Acoustic space was linked with the two dimensional30: visual space was linked with the three dimensional. Visual space was linked with the linear, sequential, print oriented space of continuous vistas and perspective. Whereas acoustic space was analogical, visual space was logical19. McLuhan related this to changing emphases on parts of the trivium32. Acoustic space thus became linked with rhetoric, visual space with dialectic (i.e. logic)33.

By 1976, McLuhan was relating these oppositions to his claims about the right and left hemisphere of the brain. The right side of the brain was acoustic: the left side of the brain was visual. The right side was simultaneous, qualitative and intuitive. The left side was linear, quantitative and logical34. These oppositions he subsequently related to his distinction between figure and ground. Figure, he claimed is visual, conceptual and deals with ascribed cause: ground is acoustic, perceptual and deals with perceived effect35.

From these oppositions emerged a particular view of history. McLuhan saw the advent of the phonetic alphabet in Greece as having set the Western mind off on a detour in the direction of the visual and the logical. The rise of printing and perspective had given undue emphasis to this visual, logical bias and were thus negative. Accordingly the left hemisphere became described as the villain36. On the other hand, electronic media, which offered a return to the acoustic, intuitive, analogical processes of the right brain emerged as the heroes of his saga of oppositional anatomical sides.

There were problems with McLuhan’s approach. He claimed that electronic media were primarily acoustic. The rise of multi-media computers has expanded the scope of electronic media to include vision as much as sound: witness the enormous rise of Computer Aided Design (CAD) packages, which rely very heavily on both vision and perspective.

At a more fundamental level, McLuhan assumed that perspective was necessarily connected with literacy. This was misleading. The Chinese were literate, had a knowledge of printing, yet developed no serious interest in perspective until the Jesuits persuaded them to do so in the seventeenth century. Islam, which produced a great literature tends, even today, to be opposed to perspectival representation of space. Nonetheless, it was in the context of literacy that western art made its gradual progress towards mastery of perspectival space. As we have shown (see Sources, pp. 155-169*, cf. below pp. 20-24*), this mastery occurred at the level of painting practice. At an intuitive level this began seriously with Giotto around 1300. Technically, if we accept Brunelleschi’s panels (c.1415-1425) as the earliest known and Masaccio’s Trinità (c.1425) as the first extant example of linear perspective, it began some 30 years before the advent of printing in the West. Early treatises consolidated this practical knowledge
in mathematical terms before the advent of printing. Even during the half century after Gutenberg, printing had effectively no impact on perspectival treatises. McLuhan's assumption that printing and perspective were necessarily linked was, therefore, untenable.

McLuhan's suggestion of connections between the development of a particular point of view in literature and a specific viewpoint in art was also misleading because it tended to conflate as if they were two, four separate factors: 1) point of view of the narrator in a text; 2) point of view of the reader of the text; 3) viewpoint established by the artist in a painting and; 4) viewpoint of a person observing the painting. Although 1) has become a popular subject of study for historians of literature (cf below pp. 116-128*) and although 2) and 4) presumably fall under the aegis of reception theory, too little work has been done, to permit a clear decision on so large a topic. As for factor 3) our brief analysis has shown that the development of perspective was not simply the fixing of a single viewpoint. Almost from the outset it involved a conscious playing with fixed viewpoints. Giedion (1941), who is said to have been a starting point for McLuhan was, therefore, also misleading in claiming that in perspective (1977, 31): "The whole picture or design is calculated to be valid for one station or observation point only. To the fifteenth century the principle of perspective came as a complete revolution, involving an extreme and violent break with the mediaeval conception of space".

As we shall show there was no such sudden break: rather, a gradual evolution. The trend towards perspective was well underway in the fourteenth century and continued after Brunelleschi’s demonstration, Alberti’s treatise, and Gutenberg’s press. A generation later Piero della Francesca wrote the first mathematical treatise on perspective. About 1492 Leonardo made the first recorded systematic quantitative experiments concerning perspective. Seventy years passed before Commandino recognized further links between mathematical projections and perspective and another seventy years passed before Desargues expressed these principles in universal mathematical terms.

McLuhan was not well understood. Eisenstein, in The Printing Press as an Agent of Change (1979,176), saw McLuhan’s claims as an incautious version of Erwin Panofsky’s analogy between the development of perspective in art and the way in which Renaissance thinkers began to look at the past from a fixed distance. Eisenstein challenged the analogy arguing that (186): “the capacity to see the past in this way could not be obtained by new optical effects devised by Renaissance artists. It required a rearrangement of documents and artifacts rather than a rearrangement of pictorial space”. According to Panofsky the development of perspective went hand in hand with the rise of modern science. This Eisenstein challenged also (269):”it is an exaggeration to launch modern science with the advent of perspective renderings and to regard pictorial statements as sufficient in themselves. A method of preserving observations as graphics records and a chance to check them against others should not be presumed to lie in an artist’s sketchpad”. Aside from these criticisms, passing comments on treatises by Alberti, Piero della Francesca, Dürer, Jamnitzer and a few general references, Eisenstein did not explore connections between perspective and printing.

Had Eisenstein understood the larger context, she could not have claimed that printing caused so sudden a revolution, or that it offered a key to problems of periodization. She
would almost certainly not have insisted that it is “an exaggeration to launch modern science with the advent of perspective”\(^{39}\). She would probably not have dismissed perspective as a lay innovation. After all most of the major examples were in the context of the church and a surprising number of them linked with a few orders (Franciscans, Dominicans, Augustinians and Carmelites). Eisenstein might well have explored the extent to which perspective offers insights into the vexed questions of continuity between middle ages and renaissance, using a periodization such as that outlined below.

As will be suggested (see below pp. 42*), this story could readily be expanded to include links between perspective and instruments: Piero’s first mathematical treatise of perspective also contained the first description of a perspectival instrument (1434). Leonardo’s notebooks which first described the inverse size distance law also contained a first illustration of a perspectival instrument (c. 1490). The period 1500-1525 brought the first printed treatises in France and Germany and a first printed illustration of a perspectival window. The period 1525-1600 saw the spread of printed treatises to the Netherlands, England, Spain, Austria and Poland. With respect to instruments it saw early attempts at a universal measuring device. The period 1600-1800 brought treatises at different levels some concerned with high mathematics (e.g., Desargues, Brook Taylor, Lambert); some with high practice (e.g., Accolti, Troili); while others were encyclopaedic (e.g., Leupold, Kästner) or simply popularizing (e.g., Dubreuil). This period also saw the development of the Galileian sector and Bürgi type proportional compass which were successful universal measuring devices. The new confidence and universality this brought to the realms of science, was reflected in the confidence with which perspective was gradually applied to the entire environment and reflected in turn in the new confidence of politicians making absolutist claims for power.

Meanwhile, other connections between perspective, texts and printing culture were suggested. Sir Ernst Gombrich, in *Art and Illusion* (1960, 129), emphasized the connection between narrative and the development of perspectival representation (mimesis, illusionism). In *Means and Ends* (1976, 32) he drew attention to: “the increasing demand for what I have called dramatic evocation, the return to the desire not to be told only what happened according to the Scriptures but how it happened, what events must have looked like to an eyewitness”. Gombrich also acknowledged that (35): “the conquest of perspective and of anatomy play their part in this story”. By implication there was a direct relationship between the re-interpretation of biblical texts and the development of perspective.

De Kerckhove (1995, 31), made the extra-ordinary claim that: “By showing the proportionate reduction of size and distance on paper as a decreasing vista from the viewpoint, the draughtsman is putting time into space.” Pictures in perspective are not per se linked with time. Often they are of timeless scenes. In the Renaissance, as will be noted presently (p. 26*), perspective introduced unexpected tensions in both temporal and spatial frames.

He also argued that "People only developed a taste for perspective during times of great pushes of alphabetization, that is, when they first learned to read the alphabet during the Golden Age of Ancient Greece and then again around the time when print was invented by Johannes Gutenberg.” According to de Kerckhove perspective (32): "could be one of
the best examples of how the alphabet re-framed the mind”. This unfortunately raised more questions than it answered. Why, for instance, did writing in Greece at the time of Homer begin a few centuries before pseudo-perspective at the time of Aeschylus? Why did perspective in the Renaissance begin prior to Gutenberg, and in Italy rather than Germany? How are we to explain that the Greeks produced pseudo-perspective, whereas the Renaissance produced perspective? Why did all the other cultures that developed alphabets, not develop perspective?

Giesecke (1991), in a fundamental study concerning the complexities of fifteenth century printing, explained the origins of perspective in terms of the surveying tradition and the optical interests of mediaeval artists. His work provided the most penetrating study to date of the implications of print culture, arguing that the development of linear perspective provided a new model for describing the world systematically which led to a new concept of truth. Giesecke was particularly concerned with the ways in which the advent of printing introduced new knowledge and a redefinition of what constitutes knowledge. In earlier cultures, (both oral and manuscript), technical knowledge had been exchanged primarily through face-to-face situations. The advent of printing introduced a quest to convey knowledge directly in book form without the intermediary of an expert, master or teacher. This posed problems because the objects to be described were no longer present as in a face-to-face situation and thus required the development of a new type of artificial sight (künstliches Sehen) that became basic to scientific description.

The early texts in the field of technical literature (Fachprosa) had a new emphasis on true (wahren) and correct (rechten) description. This, claimed Giesecke, was no co-incidence. Printing introduced a new distinction between inner and outer vision, focussed attention on objects seen by the outer eye, (dismissing everything else as invisible), and systematized new methods that came through the discovery of linear perspective. Others had made general claims about the links between printing and perspective usually with respect to the appearance of perspectival illustrations in printed books (McLuhan, Edgerton). Giesecke was concerned, rather, with the way in which perspective made persons aware that they were viewing an object from a given point of view and that complex objects needed to be viewed and represented from a series of viewpoints to be seen accurately. This led to the creation of multi-dimensional models which were then linked with geometry through Dürer's publications and in turn inspired a new type of verbalisation based on pictures which correlated a series of views.

Hence perspective did much more than add a sense of space to illustrations: it introduced a systematic methodology for describing verbally the visual world which Renaissance scientists identified as true description because of its reversibility. While Leonardo da Vinci was the first to articulate this methodology, Giesecke claims that it required the standardizing effects of printing to become established. In this way printing introduced a theory of knowledge (Erkenntnistheorie) that has dominated the West since the Renaissance. Giesecke explored the consequences of these developments for a shift in emphasis within the trivium away from logic and rhetoric in favour of dialectic (630-635). In the final part of section six, Giesecke explored how this inspired trends towards accumulation of information; new emphasis on comparison and contrast; new knowledge and even a realistic extension of fiction.
Giesecke traced how these developments led to a redefinition of knowledge (Wissenschaft). In the mediaeval tradition knowledge of nature was very much linked with physical ability (cf. the Greek techne which as Panofsky pointed out explains the close connection in German between Kunst and können). This tradition, which led to artist-engineers, assumed that knowledge involved sensori-motor and muscular skill and dexterity, whence the mediaeval emphasis on experts, experience (Erfahrnis), practical wisdom (Weisheit), and a tendency towards secrecy (Geheimnis, Arcanum). By contrast, the new approach defined knowledge as: 1) won through regulated (normierte) processes of visual perception and description or representation by an external observer; 2) stored in print form and 3) spread through a free market, which secured a commitment to dissemination or even revelation (Offenbarung) as they termed it. This led (669) to a new distinction between use (Brauch) and understanding (Verstand) and a gradual supremacy of theory over practice. Giesecke shows (672-678) that these new ideals of knowledge applied even to traditional topics as in Libavius' Alchemy.

The rise of early modern science is frequently described as a new emphasis on observation. Giesecke's analysis showed that this is too simplistic; that it was rather a question of developing a systematic method of communicating results of observation indirectly, using descriptions that reflected the objective aspects of linear perspective. Giesecke showed that this led to new links between experimenting and idealising (620-623), noting that this redefinition of (scientific) knowledge also entailed new emphasis on instruments (673). This closely argued and carefully documented work led to dramatic conclusions that "knowledge" (Wissen) in its modern sense did not exist (677) and indeed was unthinkable (655) prior to the development of print culture as it evolved in Europe. Giesecke was very sensitive to the price that was paid to achieve this (650):

Authors of technical literature (Fachprosa) and particularly their most radical representatives, "scientists" (Wissenschaftler), are forced to uniocular perception, concentration on visible characteristics (Gestaltmerkmale) and thereby to suppress more complex organs of sense and perceptions.

This monosensual focus (653) of early modern science destroyed earlier notions of unity of the senses, and required an isolation of the sense of sight which, Giesecke suggested, needed to be transcended in light of the ecological crisis that this one-sense approach to knowledge has produced. New age concerns with body language, feelings, and new relations to nature could be seen as a contemporary expression of this quest to redefine the visual bias of our culture (653). By implication the origins of perspective and printing were intimately connected with a new approach to knowledge.

Giesecke was very conscious that his telling of the story from a modern point of view meant emphasizing the new aspects of the process and that if one wished to compensate for this shortcoming one would ultimately need to retell the whole story using a mediaeval viewpoint (703). He repeatedly emphasized the gradual evolution of these developments and explicitly acknowledged their roots in mediaeval manuscript culture. He noted, for instance (668), the presence of striking morphological descriptions in the work of Albertus Magnus and Hildegard of Bingen. He accepted that there were numerous mediaeval examples of visual experience and even commitments to dissemination (677). In the case of Ortolf von Bayerland's medical book (Arzneibuch) he
described (554-55) a fourteenth century treatise with over 100 manuscripts which explicitly set out to disseminate knowledge in clear tables. In analysing the nexus of perspective, geometry, model-making and systematic representation of knowledge, he repeatedly cited Leonardo da Vinci (e.g. 617, 624, 636, 658, 663). Giesecke did not pretend that printing started the process: he claimed, rather, that printing set in motion a technological system of communication that standardized and spread the process through Germany, made it a European, and ultimately a world-wide phenomenon.

This in turn raised new questions: If printing standardized a perspectival verbal description of visual situations in the how to do it books, what set this process in motion within the manuscript tradition? As will be shown presently, an attempt to explain this shift in the concept of truth and the definition of knowledge, takes us to some of the central developments of the Middle Ages. Paradoxically, the frontiers of Gothic art, science and and culture provide unexpected and essential insights into the origins of perspective.

9. Stages

While these various explanations by art historians, psychologists, marxists, philosophers and historians of printing have provided valuable insights, they have tended to epitomize perspective as a single discovery or invention linked with Brunelleschi’s experiments rather than as a series of events. Distinctions need to be made between different media and stages and it will be useful to summarize some key chronological developments both in terms of art history and history of science.

In terms of stages, distinctions need to be made between (proto-) perspective in a loose sense of some spatial effect as in Giotto; (proto-) perspective with an approximate central vanishing point as in Lorenzetti’s *Annunciation* (Siena); perspective with a technical vanishing point as in Brunelleschi’s panels or Masaccio’s *Trinity* (Florence, Santa Maria Novella); general mathematical demonstrations as in Piero della Francesca, or precise ones as in Guidobaldo del Monte or Desargues. Hence the question of origins changes in the course of over three centuries from c. 1300 to 1636.

If we are concerned with the origins of Giotto’s breakthrough into a general spatial setting witnessed in his cycles at Assisi, Padua and Florence in the first quarter of the fourteenth century, then it is important to recall a new emphasis on narrative painting, inspired by a new attention to nature through the Franciscan Order, which became combined, largely through the English Franciscans (Robert Grosseteste, Roger Bacon and John Peckham), with a new metaphysical theology focussing on geometry and optics as a means of understanding God. The views of optics in this programme came via Witelo (c.1270) from the Arabic tradition of Alhazen (Ibn al-Haytham) who had focussed attention on the criteria for certification of sight and had brought problems of representation within the scope of optical studies.

This religious context, with its emphasis on optics, geometry and visualization of narrative, particularly Biblical narrative and lives of the saints, continued to play a significant role in Lorenzetti’s *Annunciation* (1344), said to be the first painting with an empirical vanishing point. Lorenzetti worked at Assisi and therefore drew on the
Franciscan tradition, but also did the famous panel with stories of the origins of the Carmelite order (c.1326).

<table>
<thead>
<tr>
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<th>Painter/Author</th>
<th>Work</th>
<th>Origins</th>
</tr>
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<tr>
<td>1300-1325</td>
<td>Giotto</td>
<td>St Francis Cycle</td>
<td>Narrative, Optics</td>
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<tr>
<td>1344</td>
<td>Lorenzetti</td>
<td>Annunciation</td>
<td>Narrative, Optics</td>
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<tr>
<td>1427</td>
<td>Uccello</td>
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<td>1492</td>
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<tr>
<td>1636</td>
<td>Desargues</td>
<td>Example</td>
<td>Geometry, Architecture</td>
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Fig. 2. Key events in the history of perspective with corresponding origins.

This was the same order which, a century later, commissioned Masaccio to paint scenes from the Life of Saint Peter (c.1426-1427) in the Brancacci Chapel, the first fresco cycle to use linear perspective in its technical sense, just after he had painted—for the Dominicans—the Trinity (Florence, Santa Maria Novella). What had begun as a method in painting practice gradually became linked with mathematical theory and the question of origins shifted accordingly (cf. fig. 2).

### 10. Media

Many scholars have seen perspective as a phenomenon affecting mainly painting that began with Brunelleschi and Alberti, had reached its apogee at the time of Leonardo, Michelangelo and Raphael and then declined, hence that it was specifically linked with the early and high Renaissance. Here again there is a need to distinguish among uses of perspective in different media. Elsewhere (Sources, pp. 33-35) we have shown that perspective affected a whole range of media and that these effects occurred in different places in specific contexts over a much larger span of time.

The tendency in Romanesque and Gothic churches to provide spatial doorways and to a lesser extent windows was common throughout Europe. Some windows, as in the Andreas Kirche (Braunschweig), were actually shaped in the form of pyramidal cones of vision. This provided a common framework for spatial interests within which there were national and regional differences that varied in accordance with different functions and media. Initially there had been a focus on key events in the life of Christ often balancing Old Testament prefigurations with New Testament happenings. Those countries such as France (e.g. Chartres) which used stained glass in their great rose windows to depict these events were severely limited in their spatial explorations.

This is not to say that perspective was impossible in this medium. The first stained glass window to use pseudo-perspectival effects was by an artist in the workshop of Cimabue, who produced a Coronation of the Virgin in Siena Cathedral (1287-1288), which has been called the (78): "first occasion on which the laws of perspective were used in stained glass." These techniques were developed in a Life of Saint Anthony of Padua at Assisi by the workshop of Giovanni di Bonino (1320). From there the idea went North to the the Cistercian abbey at Königsfelden (1325-1330). It was used again at
Stassengel near Graz (c.1350) where "the scenes are each enclosed within a three dimensional niche, like a sort of tower seen in perspective". At Evreux Cathedral (1395-1400), figures were placed on pedestals portrayed in perspective and in the choir of Tewkesbury Abbey in Gloucestershire, the baldachins were arranged in accordance with...[pseudo-]perspective.

In the fifteenth century a number of the early pioneers in perspective were also active in stained glass, notably, Lorenzo Ghiberti, Paolo Uccello, Andrea del Castagno and Donatello. Later examples include episodes from the *Life of Saint John the Baptist* such as the *Meeting with Craton* (1478) by Cristoforo de Mottis; from the *Story of Saint Eligius* such as the *Investiture of the Saint as a Bishop* (1480) by Niccolo da Varallo or the *Expulsion of the Merchant from the Temple* by Guillaume de Marcillat in Arezzo Cathedral (1519-1525).

These spatial explorations remained limited when the medium was mosaic as at Monreale. In Italy, where the medium became fresco as at Assisi, Padua or San Gimignano the spatial potentials increased considerably and even more so when the function changed from depicting key events in the life of Christ to narratives of saints’ lives. This quest occurred mainly on the walls of chapels in fresco, to a lesser extent in the predellas of altars and occasionally in sculptural reliefs.

In the Netherlands the scenes were almost always on altars painted in oil. The emphasis remained on the life of Christ and the Virgin, particularly key moments such as the *Annunciation*, the *Adoration of the Shepherds* or the *Virgin and Child* alone or surrounded by saints and/or donors. The spatial setting for all these scenes almost invariably involved a church. Sometimes the portal of the Church served as a window to the interior; sometimes it served more as a gate to a scene beyond; at other times the whole front facade of the church was cut away and served as a window to a scene inside the church. Occasionally the entire scene occurred inside the church. In these arrangements the portal often contained painted sculptures which continued the tradition of *Old Testament* prefigurations and parallels to the *New Testament* scene. This contrast between the old and the new law in terms of painted sculpture versus painted nature meant that the Netherlandish tradition had a quite different approach to the *paragone* tradition which in Italy contrasted the effects of sculpture and painting. At the same time the great emphasis this gave to the portal and church interior in Netherlandish art meant an early focus on sacred interior spaces that was to culminate two centuries later in the great interiors of Neefs, De Witte and Saenredam.

In Switzerland this concern with church interiors emerged with Konrad Witz in the first half of the fifteenth century. In Germany this fascination with church interiors became important in the second half of the fifteenth century with the Master of the Life of Mary (Meister des Marienlebens). In the first decades of the sixteenth century, Altdorfer and Huber developed this theme in important new ways in the context of drawings and engravings, recording actual synagogues as well as churches. In Italy, by contrast, it occurred primarily in the context of intarsia work and spread to other media such as painting in the eighteenth century (e.g. Pannini). In Italy, a trend towards secular art, showing everyday events in a sacred context, emerged largely on the walls of the public palaces of the city states, their equivalents of city halls. At the Burgundian court this
emphasis on secular events in a sacred context developed in the illustrations to *Books of Hours*.

In both sacred and secular art the chief media used included stone, paint, paper, wood, earth and plants (fig. 3). Often these media were used together either in the production of proto-perspectival or technically perspectival spaces. For instance, Giotto used a combination of architecture and paint to produce his proto-perspectival, fictive *coreto* (Cappella degli Scrovegni, Padua, 1305). This continued in the later work of Bramante (Santa Maria Presso San Satiro, Milan) and Michelangelo (Sistine Chapel, Vatican). Medium specific examples evolved in tandem. For example, in the late twelfth century, a purely architectural sculpture showing a fictive doorway was constructed in the Baptistery of the *Palace of Kings of Majorca* (Perpignan). By the early fifteenth century, Donatello, was applying proto-perspectival techniques to sculpture in stone while his contemporary, Ghiberti, applied these techniques to sculpture in bronze on the doors of the Baptistery in Florence.

Paint was one of the most complex media. In terms of fresco it was applied to panels, walls and ceilings or quadratura. Here combinations of painting and architecture were often involved. Following early exceptions such as Mantegna’s *oculus* (Camera degli sposi, Palazzo del Te, Mantua), these became the fashion in the 1560’s in Bologna with Laureti, emerging in the published literature in 1583 (Has, Danti) although it was over a century later that the most famous examples appeared with Pozzo, a trend that continued especially in southern Germany and Austria throughout the eighteenth century. Oil paintings were more specialized.

Paper was one of the most important media of perspective. Sometimes these were individual sheets. In terms of manuscripts and books, in addition to those devoted to sacred themes, there were texts devoted specifically to regular and semi-regular solids. In Italy the fashion began with Piero della Francesca and Pacioli around 1489 and culminated in the years 1496-1499 when Pacioli and Leonardo worked together to produce the *Divine Proportion* (published 1509) which was the basis for later work in the period 1568-1596 (Barbaro, Danti, Vasari, Jr. and Sirigatti). In Germany this activity began seriously with Dürer (c.1514) and effectively ended with Halt (c.1625). Another major theme was Roman ruins which, as Vasari reported, began in Italy with Brunelleschi and Donatello (c.1401). The inclusion of a map of Rome with ruins by the Limbourg brothers in the *Very rich hours of the Duke of Berry* (c. 1415-1416) attests that this interest spread quickly. Even so, systematic study appears not to have occurred until the time of Peruzzi (c.1520-1535) whose notes were inherited and published by Serlio from 1537 onwards. The period 1540-1560 saw a high point in this genre with the publications of Androuet Du Cerceau and Cock. Piranesi (1740) brought a revival. As we have shown elsewhere (cf. *Sources*, pp. 89-98*), the perspectival treatises gradually evolved a whole series of themes.

Wood also became an important medium. From the fourteenth century onwards, there were proto-perspectival uses of inlaid wood or marquetry in a sacred context, specifically choir stalls, in Italy, with the most famous perspectival examples in the period 1470-1530. In Germany and the Netherlands, where the emphasis in marquetry was rather on secular cabinets often showing combinations of ruins with semi-regular objects, the most
important period was from c.1550-1625. Wood also played an important part in stage scenery and scenography, although this typically entailed a series of media including painting and machines. From the outset pioneers in perspective such as Brunelleschi and Masaccio were also engaged in theatre decorations, although these were more by way of machines than stage scenery. Serious stage scenes emerged in the latter half of the sixteenth century (1567, 1589); did not become a regular feature until the early seventeenth century and reached their heights in the first half of the eighteenth century (e.g. 1710, 1740) with families such as the Juvarra, the Bibbiena and others.

<table>
<thead>
<tr>
<th>Medium</th>
<th>Early Examples</th>
<th>First Published</th>
<th>Famous Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stone:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Architecture</td>
<td>c. 1478</td>
<td>1521</td>
<td>1521-</td>
</tr>
<tr>
<td>Fictive “”</td>
<td>c. 1478</td>
<td>1568</td>
<td>1500-1900</td>
</tr>
<tr>
<td>Sculpture</td>
<td>c. 1400</td>
<td>1504</td>
<td>1400-1900</td>
</tr>
<tr>
<td>Paint:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fresco</td>
<td>c. 1425-1427</td>
<td></td>
<td>1430-1510</td>
</tr>
<tr>
<td>Oil</td>
<td>c. 1457</td>
<td>--</td>
<td>1484</td>
</tr>
<tr>
<td>Ceilings</td>
<td>c. 1480</td>
<td>1568</td>
<td>1500-1700</td>
</tr>
<tr>
<td>Paper (Drawings):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roman Ruinsc.</td>
<td>1400</td>
<td>c. 1550</td>
<td>1550-1580,1740-1760</td>
</tr>
<tr>
<td>Regular Solids</td>
<td>c. 1489</td>
<td>1509</td>
<td>1489-1625</td>
</tr>
<tr>
<td>Manuscripts</td>
<td>c. 1434</td>
<td>1540</td>
<td>1434-1515</td>
</tr>
<tr>
<td>Books</td>
<td>1494</td>
<td>1494</td>
<td>1494-</td>
</tr>
<tr>
<td>Wood:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marquetry</td>
<td>c. 1470</td>
<td>1567</td>
<td>1480-1625</td>
</tr>
<tr>
<td>Stage Scenery</td>
<td>c. 1567</td>
<td>1568</td>
<td>1600-1800</td>
</tr>
<tr>
<td>Earth, Plants:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gardens</td>
<td>c. 1550</td>
<td>1600</td>
<td>1550-1800</td>
</tr>
</tbody>
</table>

Fig. 3 Examples of different media that used perspective and related dates.

In Italy, perspective was applied to gardens from the first half of the sixteenth century onwards. As a topic it entered the literature with Vredeman de Vries and Androuet du Cerceau in the 1560’s. But it was not until the seventeenth century that perspective was applied to gardens on a grand scale and not until the eighteenth century that it reached its heights. It continued to be an important theme in the nineteenth century. When we examine these combinations more closely we find that some were particularly favoured in Italy (fig. 4), whereas others were favoured in the North. For example, altars were particularly developed in the Netherlands and Germany; manuscripts, particularly books of hours and histories were favoured in Burgundy and France; while the use of perspective in printed books was favoured first in Germany and subsequently in the Netherlands and France.

<table>
<thead>
<tr>
<th>Place</th>
<th>Medium</th>
<th>Italy</th>
<th>Burgundy</th>
<th>France</th>
<th>Netherlands</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walls</td>
<td>Mosaic, Fresco</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
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<tr>
<td>Chapels</td>
<td>Fresco</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Ceilings</td>
<td>Fresco</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Choirs</td>
<td>Inlaid Wood</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Altars</td>
<td>Oil on Canvas</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Predellas</td>
<td>Fresco, Tempura</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Paintings</td>
<td>Oil on Canvas</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Reliefs</td>
<td>Sculpture</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Manuscripts</td>
<td>Painting</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Books</td>
<td>Woodcut</td>
<td>*</td>
<td>*</td>
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<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Engravings</td>
<td>Ink on Paper</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Gardens</td>
<td>Earth, Plants</td>
<td>*</td>
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</tr>
</tbody>
</table>
Some themes such as gardens were explored throughout Europe but with regional variations (cf. Sources, pp. 170-182). Striking also from this overview is how the uses of perspective were initially much more diverse in the Italian context, which may be one of the central clues why perspective took nearly a century to spread to the major centres of Europe (fig. 5). In order to gain a deeper understanding of the origins of linear perspective, there are actually two interdependent strands of explanation that need to be explored: one artistic, the other scientific. The artistic strand entailed new approaches to nature and a shift in the nature of story-telling. The scientific strand entailed changes in the concept of demonstration, experiment and in the definition of knowledge itself.

11. New Approaches to Nature and Narrative

Panofsky, in his book on Abbot Suger, noted that one of the characteristics of Gothic art lay in a new approach to nature whereby one contemplated material things as a means of understanding immaterial, spiritual matters. According to Suger, who played an important role in the Cistercian order:

... when, out of my delight in the beauty of the house of God- the loveliness of the many-coloured gems has called me away from external cares and worthy meditation has induced me to reflect, transferring that which is material to that which is immaterial, on the diversity of the sacred virtues...., by the grace of God, I can be transported from this inferior to that higher world in an anagogical manner.52

Panofsky noted that one of the key sources for Suger's approach lay in the writings of Dionysius, the Pseudo-Areopagite, who used the study of visible things as a means of studying the invisible:

Every creature, visible or invisible, is a light brought into being by the Father of the lights...This stone or that piece of wood is a light to me....For I perceive ...that it exists according to proper rules of proportion; that it differs in kind and species from other kinds and species; that it is defined by its number....As I perceive such and similar things in this stone they become lights to me, that is to say, they enlighten me.53

Read narrowly, this passage would lead one simply to use examples from the material world as a starting point for mystical contemplation of the spiritual world. This, it could be argued, was essentially the path taken by Abbot Suger. Read more broadly, it could lead one to a scientific study of the physical world as a means of gaining understanding of the invisible world of God. This, as will be suggested below, was effectively the path taken by his colleague, Peter the Venerable, Abbot of Cluny, when he instigated a new search for basic texts on scientific knowledge in 1143, one year before Abbot Suger consecrated his new church at Saint-Denis.
There was more to Saint-Denis than simply a place where the visible beauty of precious stones and objects were a point of departure for invisible truths of religion. In the Latin, Saint-Denis, was Sanctus Dionysius and thus etymologically linked with Dionysius, the Pseudo-Areopagite. Saint-Denis had been the royal abbey for many centuries. It housed the tombs of Charles the Bald and Hugh Capet, founder of the ruling dynasty. Its sculptures and art reflected this historical context. At the same time it brought new emphasis to contemporary figures within this sacred and secular tradition. Hence, an Annunciation scene (c. 1140-1144), in the stained glass windows of the church, showed Abbot Suger, as a donor at the Virgin's feet. Saint-Denis also housed the Chronicle of Saint-Denis, which was begun in the early twelfth century, with a second version up to the time of Louis VIII in the thirteenth, and a third version after 1286, which included the lives of Saint Louis and Philippe III. In other words, one of the centres that helped to inspire the new realism of Gothic art, also inspired a tendency to record past and contemporary history. All this becomes the more striking when one recalls that Jean Fouquet's version of this same Chronicle of Saint Denis (1458, now Paris, Bibliothèque Nationale), was one of the first examples of (nearly correct) perspectival art in a French manuscript.

Bishop Geoffrey of Chartres was a personal friend of Abbot Suger. Geoffrey visited Suger at Saint-Denis in 1130, 1137, 1140 and assisted him at the consecration of the new cathedral of Saint-Denis on 11 June 1144. So, from the outset, there were close links between Saint-Denis and Chartres, which became the two key centres of early Gothic architecture and art.

Most descriptions of the Gothic focus on a new interest in light, a fascination with stained glass windows and a new emphasis on realistic sculpture. Mâle has suggested that the reasons for this new realism could be related to the crusades which led some French noblemen to settle in Greece. We know from Abbot Suger himself that he was personally well acquainted with the cultural heritage afforded by Rome. Speaking of columns, for instance, he noted: "we might obtain them from Rome (for in Rome we had often seen wonderful ones in the Palace of Diocletian and other Baths)". Hence the new realism would mainly be due to a re-discovery of Ancient Greek and Roman examples which, in the French context, became integrated within elaborate typological parallels between the Old and the New Testaments focussing on the Life of Christ.

More was involved, however. The Gothic period introduced a new approach to storytelling. In terms of stained-glass windows, for example, Brisac noted that the Childhood of Christ on the interior of the west front at Chartres (1150) was:

the earliest surviving example of a composition made up of three illustrated compartments at each level, and it contains a very comprehensive treatment of this period of Christ's life and also of two later events: his Baptism and the Entry into Jerusalem. Some episodes are dealt with in a sequence of several compartments. There are six, for example, in the case of the Adoration of the Magi.

These themes were continued when Chartres was rebuilt between 1194 and 1240. By the time of the Sainte-Chapelle (1243-1248), a single Story of Esther and Ahaseurus was
"told in one hundred and twenty-nine scenes" which, Brisac claimed, made it lose "its narrative precision." In the next century this apparently changed again:

Legendary windows, for example, with multiple medallions, allowed stories to be told with extraordinary narrative diffuseness, whereas in the fourteenth century only the most salient events of their subject's life were portrayed; in the case of saints, for example, it would be their meeting with Christ or their conversion to Christianity, one of their miracles and finally their glorious death. All the subsidiary episodes are dispensed with and the "reading" of the window becomes much easier.

All this becomes the more intriguing because Gombrich has suggested that the pictorial revolution which led to linear perspective had its roots in a new approach to narrative. We would suggest that this change in narrative first occurred in France rather than Italy and began seriously in the century from 1150 to 1250, which is usually associated with Gothic art and architecture. In other words, paradoxically, in the French Gothic emerged basic ingredients essential for the Italian Renaissance: not just a new commitment to realism but a whole new approach to narrative. To understand this we need to look briefly at the new subject matter of stories in the stained-glass windows and relate this to new themes in literature of the time. Then we shall stand back to look more globally at changes in the six centuries from 1000 to 1600.

**New Subjects in Windows and Walls**

A closer look at the interior stained glass windows and the exterior sculptures of the great cathedrals, reveals other aspects of their novelty. Besides introducing new realism into representations of the *Life of Christ*, their subject matter was increasingly about the lives of the saints, donors, recent champions of the faith and early founders of Christianity in the North. For example, when Canterbury cathedral burned in 1174, the new church had a series illustrating the lives of archbishops of Canterbury, such as Saint Dunstan and Saint Alphège, who lived around 1000. The Trinity and the Corona Chapels contained scenes from the *Life of Thomas à Becket*, who was murdered in the cathedral in 1170. When Chartres burned in 1194, one of the most impressive windows was dedicated to the life of Charlemagne. When the cathedral at Rouen was burned by a fire in 1200, the sculptures on the doors recorded the lives of Saint Romain, who had been bishop of Rouen from 626 to 638, and Saint Ouen, who was pope from 641 to 684.

The great cathedral at Reims, had stained glass windows (c.1160's or after) dedicated to the *Life of Saint Nicaise*, martyred by the Vandals in 407 and the *Life of Saint Remi*, who first baptized Clovis and his Franks in 498. When the cathedral was rebuilt after the great fire in 1210, these stories were integrated into the sculptures over the doorways of the North facade of the transept. The Sainte Chapelle (1243-1248), ostensibly about *Old and New Testament* parallels, emphasized a continuity between Biblical royalty and the Capetian dynasty, as embodied by Saint Louis, founder of the chapel. One set of windows was dedicated specifically to the history of relics of the passion of Christ and traced their lineage right through the Middle Ages. The images of the stained glass windows dovetailed with those in the illuminated manuscripts and hence it is not
surprising to find that one of the most impressive proto-perspectival scenes is subsequently found in the *Lives and Miracles of Saint-Louis* from the collection of Jeanne de France (Paris, BN, ms. fr. 2829, fol 11v.).

For the pre-history of perspective, this seemingly simple shift in subject matter was of the greatest importance. As long as the *Old* or *New Testament*, and particularly the *Life of Christ* remained the chief topics, artists were challenged to represent places they had never visited and persons they had never seen. To represent Christ very realistically could be seen as too personal or even blasphemous. To represent the space in which he moved in terms of local geography could equally be seen as blasphemous. When the subject matter shifted to the life of a saint, particularly a local saint, these restrictions diminished greatly. It is no-coincidence therefore that most examples of proto- and early perspective involve cycles from the lives of saints rather than the *Life of Christ* (notwithstanding, as we have discussed elsewhere, that particular scenes from his life such as the *Annunciation* were very important). Some examples of such cycles are Giotto's *Life of Saint Francis* (Assisi), Massacio and Masolino's *Life of Saint Catherine* (Rome, San Clemente), Masolino's *Life of Saint John the Baptist* (Castiglione D'Olona) and Ghirlandaio's *Life of Saint Francis* (Florence, Santa Trinità).

Donor portraits played a special role in this shift of subject matter that prepared the way for perspective narrative. Here again, Gothic art set the stage for that which the Renaissance developed. In early examples, such as Canterbury (1180), donors were typically guilds such as the furriers or goldsmiths and identified generically as such. In the course of the thirteenth and fourteenth centuries, the role of the donor became increasingly personalized to the point that they represented individual portraits. Initially donors were represented in separate spaces or peripheral to scenes in the *Life of Christ* or the life of a saint. Increasingly they became part of the same scene. By the time of the Renaissance, this had become a commonplace. In Ghirlandaio's *Life of Saint Francis* (Florence, Santa Trinità, Sassetti Chapel, c.1480), for instance, the scene showing the Pope conferring the rights of the Franciscan order on Saint Francis, was depicted with members of the Sassetti family, the Medici and famous poets such as Poliziano in attendance. This increasing specificity of the donors' portraits went hand in hand with a more precise depiction of their spatial surroundings. In the case of Ghirlandaio's fresco, for example, this entailed the Piazza della Signoria and the Palazzo Vecchio in Florence. As attention shifted to actual spaces and real, physical locations, perspective became ever more important. It is no-coincidence, therefore, that the rise of perspective was so closely linked with the history of surveying, topography and cartography.

These developments in the treatment of space had implications for concepts of time and meaning (hermeneutics). As paintings became more realistic and tended toward perspectival representation they increasingly represented contemporary scenes and events. Yet the story depicted was often in the past. So there were temporal discrepancies between the time of the painting and the time of the event depicted. To continue with the example cited above, Ghirlandaio was depicting when the pope gave the Confirmation of the rule of Saint Francis, an event that took place in 1223. Yet Ghirlandaio showed this in the context of his own contemporaries, the Medici and the Sassetti families, when he painted the picture in 1480.
Sometimes even the treatment of space was implicitly metaphorical. For instance, a detail from a manuscript of Boccaccio's *Decameron* (Oxford, Bodleian Library, Ms. Holkham Hall misc. 49, fol. 5r, c. 1450-1475) illustrates a group of young men and women taking shelter from the plague in the church of Santa Maria Novella in Florence. The picture shows an interior in perspective which appears accurate but bears no relation to the actual space of Santa Maria Novella. So although the picture appears to be perfectly realistic, the viewer is expected not to look at it literally: they need to distinguish this picture from the actual building. Hence once again perspective provokes a metaphorical 'reading of the image.

These discrepancies of temporal and spatial frames had consequences for the meaning of the picture. The viewer had to become conscious of a temporal discrepancy, to distinguish the contemporary figures (of 1480) from the historical ones (of 1223): i.e. to see the scene metaphorically and not literally. Paradoxically, the more realistically and literally painters recorded their surroundings, the more metaphorically and not literally viewers had to see these paintings. So the growth of perspectival realism and the rise of new levels of interpretation go hand in hand. As we have discussed at greater length elsewhere (*Sources*, p. 185), it is probably no coincidence that Dante introduced his distinction between four levels of interpretation (literal, allegorical, moral and anagogical) in the same decade (1300-1310) that Giotto painted the Arena Chapel in Padua and his students were finishing the great fresco cycles in the upper church of San Francesco in Assisi.

As a result of these shifts in subject matter, and new treatments of space and time, pictorial cycles integrated historical and contemporary secular themes within the Christian context, or rather, they placed Christian themes within a larger historical framework, which established a continuity between Antiquity, Middle Ages and the present. There was, therefore, not just a re-discovery of Ancient examples, but rather a discovery that pagan Antiquity and Christian Middle Ages were part of a single historical tradition. As these connections with everyday life became the more manifest, the need for perspectival narrative became ever more necessary.

**New Literature**

Gothic art in the form of stained-glass windows and sculpted walls involved much more than a simple shift in subject matter. It entailed fundamental changes in narrative: what kinds of stories were chosen, how they were told and how they were presented. These changes affected literature as much as art. A variety of influences help to explain why these changes occurred. For instance, the Arabic tradition of story-telling, which came to Europe via Mozarabic Spain, probably had a direct influence on the troubadours in Provence. The troubadours developed themes of courtly love, a secular version, so to speak, of the cult of the Virgin.

These Provençal troubadours influenced the trouvères in Northern France, who also drew on the so-called Brittany corpus (*matière de Bretagne*), that was linked with English story-telling. The trouvères, in turn, influenced the German *Minnesänger* tradition. We are told that the realism of the northern trouvères gradually led them away from the quintessential love themes of the south. Arras became a centre for some 180 poets of whom the most famous were Jean Bodel, Adam le Bossu and Baude Fastoul in the
thirteenth, with Christine de Pisan, Alain Chartier and Charles d'Orléans in the fourteenth century. Aside from the obvious literary qualities in Christine de Pisan's writings, it is noteworthy that this author, who helped bridge the French and Italian traditions, also inspired some of the most dramatic proto-perspectival illustrations in the illuminated manuscript tradition.

As in the case of art and architecture, the subject matter of Gothic literature continued to emphasize religious themes, particularly typologies linking the Old and New Testaments. At the same time there was increased attention to secular themes. These secular themes differed from traditional examples in three important ways. First, they introduced a new emphasis on illumination which, besides its purely metaphysical connotations, had a very practical purpose. The beginnings of chapters were illustrated to make the manuscripts much easier to use and thus helped with the classification and ordering of knowledge. Second, they introduced the concept of first person narrative (see below p. 153*), bringing to story-telling an aspect of individual viewpoint which prepared the way and in a sense made necessary the development of linear perspective.

Third, they focussed on externalizing and rendering visual, internal, psychological aspects. The roots of this approach lay in Antiquity. The Greeks and Romans had represented basic concepts such as war (Mars), human virtues such as wisdom (Pallas Athene) and human emotions such as love (Eros) in terms of beings which could then be sculpted and painted. As Auerbach has convincingly shown this Greco-Roman pantheon remained very impersonal, with no real exploration of character. According to him the roots of a more personal approach came strictly from the Judaeo-Christian tradition with its roots in the Old Testament.

The story is more complex. The Provençal poets, aside from probable Arabic influences, lived in a part of France known for its heretical tendencies, largely inherited from the Bogomils, which became infamous through the Albigensians against whom Saint Dominic waged war through the Dominican order. On the surface Saint Dominic won the day. Ironically, however, many aspects of the Provençal approach to story-telling, lived on in the Christian conquerors. Whence, the Christians, in fighting the heretics, became the enemy, insomuch as they partially acquired their methods.

In all there were over 400 troubadours in the twelfth and thirteenth centuries, some thirty of whom were Italian provencalists. These included Sordello di Mantova, Cielo d'Alcamo, Rinaldo d'Aquino, and Odo delle Colonne. The troubadours' story-telling methods lent themselves to visual renditions. The songs of the troubadours had an influence on Dante and were an important source for the stories of Boccaccio (1313-1375), particularly his Decameron (cf. pl. ***). The troubadours' heritage had an even greater impact on the songs (canzone) of Petrarch (1304-1374) who, it bears remembering lived in Avignon and visited Paris, Lyons, Liège, as well as Ghent and Cologne. It is surely no co-incidence, therefore, that it was particularly the verses of Dante (cf. fig 6), stories of Boccaccio and the triumphs of Petrarch (as witnessed particularly in Mantegna), that tended to be illustrated in manuscripts and rendered in pictorial form. The troubadours favoured vernacular, literal treatments of the Bible, an approach that Saint Francis of Assisi followed and which found itself expressed visually on the walls of the church of San Francesco in Assisi through the art of Cimabue, Giotto,
Lorenzetti and others. Italy thus made famous French innovations: or rather put into frescoes and paintings what the French had painted in words and illustrated in manuscripts.

So the roots of the new approaches to story-telling that led to perspective lie not simply in the Old Testament as Auerbach would have claimed, nor just in a re-discovery of Antiquity as is often asserted, but rather in the discovery of a historical continuity linking the middle ages with both the past and present. And some role was played by pagan strands via the heretical troubaours, which were assimilated by the Christian crusaders. This becomes the more evident if attention is turned to the five basic topics in literature of the time: classical stories; mediaeval knights engaged in courtly love; historical stories relating to Charlemagne; histories of the crusades and psychological allegories.

In terms of classical stories one of the earliest (end of 11th - beginning of 12th century) was the Romance of Alexander the Great. Thereafter, the three most famous examples were all written within a twenty year period in the second half of the twelfth century, namely, the Romance of Thebes (1150-1155), the Romance of Troy (1165) by Benoit de Saint-Maure and the Romance of Aeneas (1160-1170). These classical themes remained important. An anonymous Ancient History until the Time of Caesar (1206-1230) led to some forty illustrated manuscripts. Guido delle Colonne's History of the Destruction of Troy (finished 1287) was translated into almost every vernacular language. A fourteenth century Entry of Theseus into Athens (Vienna, ONB, Cod. 2617, fol. 39) contains another of the outstanding examples of proto-perspectival space in the illuminated manuscript tradition, which again has links to the narrative tradition in stained glass. It is noteworthy that actual historical accounts such as the travels of Marco Polo were frequently referred to as the Romance of the Great Khan and were sometimes even bound with the Alexander Romance (Bodleian Library, Ms. Bodley 264). So legend, story and history dovetailed. It is equally noteworthy that the first printed book in England was William Caxton's Recuyell of the Histories of Troy (1473-1474) and the first English printed book with illustrations was Caxton's Mirror of the World (1481), based on Vincent of Beauvais' Historical Mirror. These historical themes were seen as a top priority by one of the fathers of printing.

A second important theme focussed on mediaeval knights. Famous in this respect was Chrétien de Troyes (c.1130-c.1227), best noted for Lancelot and the cavalier of the wagon, Yvain and Parsifal. Lancelot was the first French literary work to be illustrated and later books followed the methods developed therein. These books by Chrétien drew heavily on Arthurian legends. It comes as no surprise, therefore, to learn that Chrétien de Troyes is said to have visited England. Chrétien de Troyes was emulated by Thomas d'Angleterre (c.1170), Béroul le Jongleur (c.1190) and by the authors of Tristan and Isolde. By the early twelfth century, depictions of the life of King Arthur were found in the Italian cathedrals of Modena and Otranto. In the thirteenth century, the Arthurian themes were developed in Mallory's famous Death of Arthur (Mort d'Arthur).

It is striking that this shift in new themes came at a time when both the producers and patrons of manuscripts were changing. During the Middle Ages monks had been the prime producers and the patrons had generally been monks, missionaries and emperors.
From the mid-twelfth century onwards, as the universities emerged, the production of manuscripts shifted increasingly to lay persons. Apparently it was particularly minor nobles who commissioned and enjoyed reading romances of King Arthur and his knights. So the new themes involved both new secular producers and patrons.

Connected with this Arthurian tradition, but with a firmer basis in history, was a third theme focussing on events in the eighth and ninth centuries. This had its roots in the chronicle literature. As early as the eighth century, the *Chronicle of Frédégaire* had recounted events in the period 584-642. A second, the *Chronicle of Turpin*, also known as the *History of Charlemagne and Roland*, was written in Santiago da Compostella (one of the four main pilgrimage sites of Europe) at the end of the eleventh century and served as a sort of guide-book for pilgrims. It is well known that the pilgrim routes to Spain played an important role in the spread of Romanesque and subsequently of Gothic art. It also appears to have affected awareness of historical roots and story-telling. Thus Chaucer's tales told by pilgrims on the way to Canterbury were part of a larger pattern.

In terms of twelfth century literature, the earliest treatment of the theme of Charlemagne was the famous *Song of Roland* (1100-1125), which dealt with events on the fifteenth of August, 778. It was said to have been inspired by pilgrims who found the tomb of Roland on their pilgrimage to Santiago da Compostella, and was a topic taken up explicitly in the window of Charlemagne at Chartres. The same two decades that brought the three classical Romances of Thebes, Troy and Aeneas, brought the *Romance of Brut* (1155) and its sequel, the *Romance of Rou or Deeds of the Normans* (1155-1170) both by Wace. About three decades later (c. 1200) there followed the *Song of the Saxons* by Jean Bodel, which told the story of Charlemagne's expedition against Widekind.

A fourth theme dealt with the crusades. Here, one of the earliest examples was the *Song of William* (end of 11th -beginning of 12th) by Garin de Monglane, which told of the exploits of William of Orange against the Saracins in the region of Arles. There followed the *Song of Antioch* (c.1180), by Graindor de Douai, which recounted events of the first crusade until the taking of Antioch (1098) and the *Song of the Crusade against the Albigensians* (1207-1218). The *Song of Aspremont* (c.1240-1250) told the story of the knights of Philip Augustus and Richard the Lion Heart in Sicily during the winter of 1190-1191 during the third crusade against Saladin. The same workshop that produced this work probably illustrated a romance on the chivalric adventures of Alexander the Great, the *Romance of all Chivalry* (1240-1250).

A fifth theme was essentially psychological. One aspect thereof had its roots in Aesop's *Fables*, yet the mediaeval fable (*fabliau*) literature, linked with bestiaries, imbued this tradition with a much deeper personal dimension. One of the earliest of these was *Richeut* (before 1170). The most famous of these psychological portraits of virtues and vices was the *Romance of the Rose*, begun by Guillaume de Lorris (1236) and finished by Jean De Meung (1275-1280). The visualization of psychological aspects which this implied, was taken further in the Lower Church of San Francesco in Assisi where obedience, ignorance along with other virtues and vices were carefully represented. In the Renaissance, Mantegna would take this theme one step further.
On its own any one of this themes amounts to little more than a passing chapter in the history of literature. Cumulatively, the thrust of these classical stories, tales of mediaeval knights and courtly love; Arthurian legends, chronicles of the crusades and fable literature, introduced important worldly themes into a predominantly religious context. A framework which initially focussed on symbolic and typological meaning thus gradually shifted to include more everyday events. Depictions of eternity gave way to narratives involving changes in physical space or time. Typological parallels between Old and New Testaments originally sought to find Old Testament precursors for the Life of Christ. The shift to secular narrative meant that there could now be parallels between the Life of Chist and the Life of Saint Francis as occured at Assisi. Or there could be lives of saints as an independent theme. Abstract symbols gave way to real life donors and other depictions of human activity.

An important characteristic of these new themes in literature was that they went far beyond verbal expression. The new stories were often illuminated, i.e. they had accompanying visual versions of the stories. These images in manuscripts were, moreover, frequently copied or adapted in stained-glass windows, painted frescoes, sculpted stones and elsewhere. Literature and art thus became increasingly interdependent.

**History, Mirrors and Visual Knowledge**

To put it differently: stories gave way to histories and history became inherently visual. This may sound as if it were merely a clever turn of phrase, but it actually reflects profound changes. As early as the sixth century A.D., the Latin term *historia* was used to refer to a pictorial representation of an event. This meaning became particularly significant in France. In addition to an obvious meaning of "telling of memorable and true events," *histoire* meant the "representation of a scene with several persons, the illustration of a history book" and was sometimes synonymous with "painting, drawing or representation". The verb *historier* came to mean, "to represent events," or more precisely "to represent through a painting or a miniature (an historical scene)."

Another connotation linked history with truth. Hence the adjective, "historical", was synonymous with "veridical". Which helps us to understand the term "natural history", in which history was linked with science, knowledge and understanding of the various productions of nature. In Italy, the oldest pharmacopia as we now know it, the *Florentine Recipe Book*, mentions that "nearly all the plants and other natural objects have been clarified by the history with the eye itself and with irrefragible testimonies." Whence, the term, "history", acquired a more powerful meaning as "systematic description (of a plant, of an animal)."

We have encountered a variant of this concept earlier. Giesecke, it will be recalled, claimed that this kind of systematic description was first introduced by the printing process and therefore argued that printing played a crucial role in the establishment of a new sense of veracity in the sense of scientific truth. We can now assert that it began long before the printing press in the West, while continuing to accept that printing helped enormously in establishing this on a more universal basis.
When precisely did this new approach to history as a systematic scientific approach begin? Illustrations in literature began, as we have seen, with *Lancelot*, and spread through texts such as the *Romance of the Rose*, the *Canterbury Tales* and the *Divine Comedy* (fig. 6).

<table>
<thead>
<tr>
<th>Author</th>
<th>Title</th>
<th>Manuscripts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anonymous</td>
<td><em>Lancelot</em></td>
<td>50</td>
</tr>
<tr>
<td>Guillaume de Lorris and Jean de Meun</td>
<td><em>Romance of the Rose</em></td>
<td>200</td>
</tr>
<tr>
<td>Geoffrey Chaucer</td>
<td><em>Canterbury Tales</em></td>
<td>85</td>
</tr>
<tr>
<td>Dante Alighieri</td>
<td><em>Divine Comedy</em></td>
<td>1200</td>
</tr>
</tbody>
</table>

Fig. 6. Examples of some of the great mediaeval illustrated literary texts and approximate numbers of manuscripts.

To understand these developments it is important to trace the changing role of the eye in the acquisition of knowledge. The notion that the eye played a central role in learning had been acknowledged by Plato in the *Timaeus*. Subsequently, philosophers such as Philo of Alexandria, Augustine and Alcher of Clairvaux distinguished between three kinds of knowledge, corporeal, spiritual and intellectual, which they associated with the eye of the body, reason and contemplation respectively.¹²⁶ These three paths were in a hierarchy such that the carnal eye was frequently associated with illusion and limitation whereas the eye of contemplation was that to which one aspired. By the twelfth century Saint Bernhard of Clairvaux maintained this distinction but acknowledged that one could see God in all creatures, i.e. even the physical eye could lead one to God.¹²⁷ Hugh of Saint Victor (1118-1140) went further to claim that "if we wish to raise the eye of the spirit to the invisible, we need to contemplate the similarities of visible things as traces of understanding."¹²⁸

In the *New Testament* (*Corinthians 13,12*), Paul used the metaphor of looking into a glass darkly (i.e. a mirror) to describe how we know God.¹²⁹ Mediaeval thinkers typically compared the eye to a mirror.¹³⁰ Metaphorically the eye became the mirror of the heart.¹³¹ Moreover, the Holy Scripture was also described as like a mirror of the mind, such that things inside us are seen.¹³² This image can be traced back to John Chrysostomus (344-407) and Augustine (354-407), and was used by Hugh of Saint Victor (1118-1140) and Saint Bonaventure (1221-1274). Mystics such as Meister Eckhart (1260-1328) claimed that one needed a mirror to see God.¹³³ The Virgin Mary, Christ and the saints were to be seen as mirrors.¹³⁴ Some authors deliberately referred to both figurative and literal mirrors. Albrecht von Scharfenberg, for instance, described the knights Akuleis and Mecka who were metaphorically mirrors but at the same time carried real mirrors in fighting basilisks.¹³⁵

This visualization of interior qualities (cf. theme five above) was closely linked with the use of metaphors of vision in the moral domain. Chrestien de Troyes, for instance, explored the theme of the eyes as a mirror of the soul in his *Cligès*.¹³⁶ Around 1230, Petrus de Limoges, wrote an anonymous *Treatise on the moral eye*,¹³⁷ which was variously attributed to John Peckham, Robert Grosseteste, Duns Scotus Johannes Gualensis, Hugh of Saint Victor and Thomas Bradwardine.¹³⁸ Schleusener-Eichholz
(1978) has drawn attention to the interplay between the development of this visual allegory and scientific concepts such as experiment.

The metaphorical use of mirrors to reflect inner virtues gradually shifted to refer to external objects. Nicolaus von Strassburg claimed that all creatures were as a mirror in which God was reflected. Meister Eckhart and Saint Bonaventure claimed that the whole of creation was a mirror. A next step was taken by the Dominican encyclopaedist, Vincent of Beauvais (c. 1190-1264), who wrote a Natural, Historical and a Doctrinal Mirror, which were combined under the title Greatest Mirror (c. 1244-1260). His Natural Mirror was a record of natural history in the sense explained above. His Historical Mirror began with the creation of the world and ended with the crusade of Louis IX in 1254. His Doctrinal Mirror added another 17 chapters. An anonymous author subsequently added a Moral Mirror (c. 1310-1325). The initial Latin manuscripts were not illustrated, but once translated into Middle Dutch (1330) and especially into French (1332) many illustrations were added. Gradually these figurative images of mirrors reflected physical reality, discussions of mirrors, were reflected so to speak in illustrations. Later the quest emerged of using physical mirrors to record that physical world. So verbal descriptions as if they were visual emerged in the period around 1250 even though the visualization this implied was not explored until some eighty years later and not fully exploited until 150 years later at the time of Brunelleschi's demonstrations.139

As a result the image of the mirror as a reflection of Nature, God, truth and history, in the sense of representation of true events, became intertwined: true depictions, visual illustrations, history and mirrors became ever more synonymous. Besides Vincent of Beauvais' Mirror of History, there was an anonymous Historical Bible (1291-1295), the very years that Giotto began work at Assisi), based on the Scholastic History of Petrus Comestor, which linked these themes of historical and scientific truth with theological truth, and inspired some seventy illustrated manuscripts.

If we look to Italy, it is striking that the breakthroughs in visual narrative came in the context of French narratives as in the town hall at San Gimignano in the period 1280-1300 in the so-called Room of Dante. It is all the more striking then to discover that the definition of history as a "representation, painted or sculpted of a subject or contents taken from a sacred or profane [his]story, from mythology etc. In a concrete sense: painting or sculpture which represent such a fact or such events"140 was introduced into the Italian language by Dante. Hence, where the French had interpreted history to be a visualization usually in terms of miniatures in manuscripts, Dante interpreted history to include paintings and sculptures on walls. His heightened approach to visualization thus helps explain not only the vast increase in illustrated manuscripts (cf. fig. 6), but also why the themes of the Divine Comedy soon began to populate the walls of monasteries, churches, and even secular buildings. This led to Leonardo's definition as "decorating a surface (a panel, wall etc.) with a representation in painting or sculpture with historical, sacred or legendary facts, linked together by a narrative nexus."141 Hence, by the late fifteenth century history, sacred accounts and legends were being distinguished anew, but narrative remained a key.
To return to the thirteenth century, this new approach to narrative meant that the same impulses which brought realism, and a sense of individuality to the statues of cathedrals; brought new attention to the importance of saints and contemporary donors and brought a personal viewpoint to story-telling and a new richness in artistic expressions of story-telling. The same Gothic influences which changed the nature of story-telling in literature, transformed the sculptures of Naumburg (c. 1213-1242)\textsuperscript{142}, and led to the first stained glass windows on the \textit{Life of Saint Francis} at Erfurt (c.1220-1230)\textsuperscript{143}. Paradoxically, while we have traditionally thought of the Gothic as somehow opposed to the Renaissance, the new realism of the Gothic helped to provide the essential narrative impulses that made possible Renaissance perspective.\textsuperscript{144}

A sceptic might rightly object that this is not yet a full explanation. Even if we agree that the new realism of early Gothic art at Saint Dénis (1140-1144), the west façade of Chartres (1150) and later at Canterbury (1180), was an important ingredient for perspective, it remained, as the economists would say, a necessary but not sufficient condition for perspectival realism. The same argument can be made for the magnificent examples of Gothic art at its height, be it Chartres after the fire (1194-1240), Reims (c.1150, 1210 onwards); the Sainte Chapelle (1243-1248) or Tours (1260). The stories became more realistic, more secular. There were more spatial elements, yet they were still not perspectival. Meanwhile, Italy had other traditions. In Rome, there was quite a different tradition of narrative cycles which, by the time of Cavallini, had proto-perspectival elements. But this too was far from linear perspective in all its rigour. So what was the missing ingredient?

We would suggest that the answer may well lie in new interplay between the traditions of Northern Europe and those of Italy,\textsuperscript{145} a theme which Castelnuovo (1966) and Ragghianti (1977) have explored with respect to the fifteenth century. The various orders had a network of monasteries which connected the whole of Europe. These connections were stronger when a northern cleric gained a high position in the Church. Gerbert, who became Pope Sylvester II, was an early example. Urban IV of Troyes was another example, and all the more interesting in this context. Besides being the birthplace of Chrestien of Troyes, whose stories introduced new aspects of narrative, and a place the cathedral windows of which were one of the first great expressions of Gothic narrative art (1170),\textsuperscript{146} it was the town, less than a century later, where a new mood in painting was introduced:

\begin{quote}
 at Saint Urbain in Troyes, a church built by Urban IV on the site of his birthplace and on which work began in 1262....On the upper story the figures of the prophets, which accompany a crucified Christ surrounded by the Virgin and Saint John, are placed beneath architectural baldachins... Portrayed either in full or three quarter profile, with a strongly expressive feeling of action, these figures seem to be endowed with a strongly expressive feeling of action.\textsuperscript{147}
\end{quote}

The pope, at the time, was based in Viterbo and would have been fully informed of these developments. For a person in Italy to learn about the latest trends in Northern realism was nothing new. Different and, possibly seminal, was a particular constellation of events at the time. The date was 1262. Three years later in 1265, Urban IV's successor, Pope Clement IV in Viterbo, commissioned Roger Bacon to write the \textit{Greatest Work (Opus}
Maius), which gave an epistemological (see below p. 41*), as well as a theological basis for a new emphasis on visual veracity through visual representation. Whereas Bacon's predecessors had seen the visible as merely a stepping stone towards the invisible, Bacon claimed that the visible played a crucial role in this understanding. Indeed, he claimed, that an exact knowledge of scientific phenomena was pre-requisite for an understanding of the spiritual sense that lay buried within.¹⁴⁸

Edgerton (see above p. 8) and Bergdolt¹⁴⁹ have already drawn attention to a key passage in Bacon's Greatest Work, but it is necessary to cite it again at some length in the context of our discussion. Bacon was considering the uses of geometry. After mentioning the obvious applications to 1) astronomy, 2) geography, 3-4) chronology (in different aspects), he turned to its use 5) in Biblical interpretation or hermeneutics. Here, he linked geometry with picture-making. Geometry combined with art in the form of picture-making thus became a key to unravelling the secrets of the Scriptures. In Bacon's own words:

> it is impossible for the spiritual sense to be known without a knowledge of the literal sense. But the literal sense cannot be known unless a man knows the significations of the terms and the properties of the things signified....it is not possible for the literal sense to be known unless a man have these works depicted to his sense, but more so when they are pictured in their physical forms; and thus have the sacred writers and sages of old employed pictures and various figures, that the literal truth might be evident to the eye, and as a consequence the spiritual truth also....But no one would be able to plan and arrange a representation of bodies of this kind, unless he were well acquainted with the books of the Elements of Euclid and Theodosius and Milleius and of other mathematicians.¹⁵⁰

This was written in 1265. As will be noted below, four years later in 1269, William of Moerbecke in Viterbo was translating these works, and almost immediately afterwards Witelo, also in Viterbo, used this translation as the basis for Book one of his great work on Optics (Perspectiva) which he dedicated to Moerbecke. In the Opus maius, Bacon went on to express what he hoped would happen: his version of a wish-list:

> Oh, how the ineffable beauty of divine wisdom would shine and infinite benifit would overflow, if these matters relating to geometry, which are contained in Scripture, should be placed before our eyes in their physical forms! For thus the evil of the world would be destroyed by a deluge of grace, and we should be lifted on high with Noah and his sons and all animate creatures collected in their places and orders.... Surely the mere vision perceptible to our senses would be beautiful, but more beautiful since we should see in our presence the form of our truth, but most beautiful since aroused by the visible instruments we should rejoice in contemplating the spiritual and literal meaning of the Scripture, because of our knowledge that all things are now complete in the Church of God, which the bodies themselves sensible to our eyes would exhibit. Therefore I count nothing more fitting for a man diligent in the study of God's wisdom than the exhibition of geometrical forms of this kind before his eyes. Oh, that the Lord may command that these things may be done! There are three or four men who would be equal to the task, but they are the most expert of the Latins.¹⁵¹
The passage would seem to be a plea to do a full scale mural version of an illustrated *Bible* as a key to hermeneutics and a deeper understanding of the spiritual truths of the *Old* and *New Testaments*. Yet how could Roger Bacon, an Englishman living in Paris at the time, express this wish when he would have seen the Sainte Chapelle and very likely have been aware of Chartres? Was it just a question of wanting a narrative in painted fresco than in stained glass? Perhaps it is significant that he specifically referred to Latins, by which he presumably meant Italians.

A typical Italian of the time would have used some geometry in doing their painting but would have continued the focus on traditional symbolism thus putting severe limits on the potential naturalism of their work and precluding a proto-perspectival treatment. Roger Bacon was, however, a Franciscan. Living in France, he would have been fully aware of the tradition of the troubadours emphasizing vernacular versions of scripture, which Saint Francis had adopted. He would have been equally aware of a Franciscan tradition, again borrowed from the troubadours, of acting out their stories. In this context the *Birth of Christ* became transformed into scenes with a real manger and live, local shepherds. The *Life of Christ* was not just a story to be read. It was something to be re-lived by Saint Francis and indeed by all his followers. If we are right then Bacon's wish-list was not just for another *Life of Christ* using some geometry, but rather a *Life of Christ* which would be paralleled with a *Life of Saint Francis*, in order that obscure meanings of the scriptures could be exemplified in terms of everyday events in the life of the founder of his order.

All of this becomes the more fascinating if we remind ourselves of the chronology of events surrounding the famous frescoes at Assisi. If we accept Poeschke's dating then the Saint Francis Master had begun working in the lower church of San Francesco around 1260. At the time Bacon was writing the Gothic Master had arrived on the scene (1265-1270), to be followed by the Roman Master (1270-1280). By 1280, Cimabue was beginning a more systematic approach which was then carried out successively by Giotto (1290-1300, 1320), the Giotto School (1300-1305, 1315-1320), Lorenzetti (1315-1320,1325-1330) and Martini (1320-1325). If we are right then Bacon was calling for a systematic decoration of Assisi which began almost immediately and took some sixty years to complete. The result was something that may be remembered as uniquely Italian, yet would not have been possible without a French connection, and for that matter, an English connection. This interplay of North and South continued in the early fourteenth century. Simone Martini from Siena, for example, who contributed to Assisi, also spent time at the papal court in Avignon.

As we shall see presently, the pope, who commissioned Roger Bacon to write his *Greatest Work* (*Opus maius*), had done so with quite another purpose: to put learning on a new track that would avoid the excesses of Aristotelian logic of the Dominicans and the tendencies towards Platonic mysticism of the Franciscans. Bacon set out to find a new goal for knowledge in experiment based on mathematical truth. We shall show that it was ultimately the combination of this scientific and larger, epistemological goal, that transformed the proto-perspectival exercises of Assisi into the mathematical perspective of the Renaissance.
However, before turning to the scientific origins of perspective, it will be useful to make two brief excurses. First, we shall stand back and summarize some of the major shifts in spatial representation from the eleventh through to the seventeenth century in order to get a big picture. Second, we shall look at three characteristics of perspective, namely, its capacity for relating, emphasizing and varying scenes. This is essential if we are to understand how, and why the tool that began as an aid to narrative, simultaneously undermined many of narrative's premises.

**Romanesque (c. 1000- c. 1200) and Gothic Periods (1140- c.1399)**

One strand of the classical heritage that particularly fascinated the middle ages was a neo-Platonic tradition that focussed on the concept of light. Through Plotinus, Augustine, Dionysius the Pseudo-Aeropagite and John Scot, light became a key to understanding the visible world and the visible world a basis for comprehending the invisible world beyond. Hence it was that the chain of being which in the Manichean tradition served as a rationale for rejecting the physical world, became in the Christian tradition the reason for accepting, studying and depicting the visible world of God's creation. As we shall see presently, the English Franciscans, notably Grosseteste and Bacon, found in light an explanation not just for the multiplication of species, but for the origins of the physical world: their version, as it were, of atomic theory. This generated both new interest in the metaphysics of light through authors such as Pseudo-Witelo and new studies of the physics of light, through optical writers such as Bacon, Witelo, Peckham, and their followers. The shift from Romanesque to Gothic began partly as an exploration of how visible light could have metaphysical effects and led to the magic of Chartres. This focus on the forms of light subordinated and tended to obscure the contents of the windows through which the light passed. From the mid-twelfth century onwards however, the contents of the windows increasingly competed with the forms of light that made them visible, as narrative became ever more important.

In terms of fresco painting, narrative had always played some role. With the Carolingian revival famous monasteries such as the Reichenau had introduced some narrative cycles, but these remained the exception. After the year 1000, as the barbarian invasions receded, Europe entered into a new stability. As Christians realized that they had entered safely into a new millenium, they built new churches by way of thanksgiving. They also gave new attention to biblical stories and their pictorial representation. This began in terms of specific parts of churches such as doors (Verona, Hildesheim), ceilings (Hildesheim), and later rose windows (Reims, Chartres, Paris, York). Symbolic harmony determined the arrangement of individual elements into a coherent whole. Story-telling was gradually extended throughout the entire space of the church as in Monreale and Wienhausen. These masterpieces of later mediaeval art were effectively symbolic *Summa* which paralleled the philosophical efforts of Hugh of St. Victor, Albertus Magnus and Thomas of Aquinas. In terms of contents, faith was dominant, i.e. Christian values. In order to relate these images more systematically, proto-perspectival elements were introduced in subsequent examples, beginning with individual, often isolated, architectural elements and other objects. This development of isolated spatial forms was one strand in the rise of perspective.
A second strand entailed the development of spatial context through interior rooms and exterior landscapes. This owed much to the secular literature ranging from the Provençal, courtly love poems and Arthurian legends to chronicles which linked historical events with contemporary happenings such as the crusades. This second strand emerged partly in France, but predominantly through the Burgundian Court, which brought the rise of Netherlandish art. Elsewhere, in Siena, Simone Martini also introduced a new emphasis on spatial context in his famous frescoes in the Palazzo Publico. Connections through the papal court of Avignon, brought interplay between the French and Burgundian traditions and these Sienese developments, partly through the direct sojourn in Avignon of Simone Martini himself. In the next generation, the Sienese tradition evolved through painters such as the Lorenzetti brothers and Giovanni di Paolo.

These two strands of spatial mastery, namely, spatial forms (isolated objects) and spatial contexts (interiors, landscapes) evolved in parallel. Their integration came slowly. Assisi can be seen as one of the first attempts at synthesis. Giotto's *Saint Francis* cycle (c. 1290-1300) dealt with both spatial objects (such as a niche, a chapel or an interior) and spatial contexts (a landscape with figures). Giotto's subsequent cycles in the Arena Chapel at Padua (1304-1308) and the Peruzzi Chapel in Santa Croce (Florence, c. 1327) pursued this quest as did Lorenzetti's work in Siena and Assisi during the 1330's and 1340's. Further experience led Lorenzetti (1344) to master these proto-perspectival elements and discover practical solutions in terms of vanishing points.

**Renaissance (1400-1500)**

The better part of a century passed before these practical solutions led to practical demonstrations by Brunelleschi (c.1415-1425) and almost as much time again before these practical demonstrations had been transformed into quantitative experimental demonstrations by Leonardo (1492). In the course of the fifteenth century artists also discovered that perspectival elements which emphasized scenes offered new possibilities in creating variations thereof. Spatial harmony now outweighed symbolic harmony. The key developments in these new explorations took place in Florence in chapels such as the Brancacci in the Chiesa del Carmine, in Santa Croce; in Santa Maria della Novella and Santa Trinità. With respect to contents, (sacred) faith and (secular) reason were treated increasingly on equal terms.

**High Renaissance (1500-1527)**

These principles were then applied to an entire space such as the Sistine Chapel or the *Stanze* in the Vatican. By now spatial harmony of the individual elements determined symbolic harmony and gave the whole a dramatically new effect. In order to appreciate the element of continuity, it is instructive to compare the ceiling at St. Michael’s, Hildesheim, with the Sistine Chapel in the Vatican. Their basic elements are surprisingly similar: both have central panels with episodes from the *Old* and *New Testaments*. Both are flanked by religious prophets and pagan sibyls. But Michelangelo’s version has a number of additional elements: further *Old Testament* scenes in the roundels, Christ’s forebears, the children of Israel, etc. We are back at Panofsky’s theme of Renaissance and Renascences. There is a continuity between St. Michael’s in Hildesheim and the Sistine Chapel in the Vatican. What sets them apart is that organization in Saint Michael’s is a principle of harmony based mainly on symbolic elements, usually in
simple parallels or oppositions as in *Old versus New Testament*; whereas organization in
the Sistine Chapel is dominated by spatial harmonies, allowing a much more complex
interplay of related themes with greater emphasis and variation. Raphael developed these
potentials in the *Stanza*, maintaining the assumption that the frame was the key to spatial
harmony. But in terms of contents, Christian and pagan elements now vied with one
another: faith was being challenged by reason.

Mannerism (1527-1600)

Mannerism questioned this assumption that a frame was the key to this spatial harmony
as in Fontainebleau’s *Galerie François Ier* or the Villa Maser. Balanced spatial elements
as a principle of organization were thus abandoned as, for instance, in Giulio Romano’s
*Room of the Giants* in the Palazzo del Te at Mantua. In terms of contents, faith and
reason were now often in conflict. Meanwhile, the spread of printed picture books with
perspectival examples created new ambiguities between ancient and modern, ideal and
real buildings, provoking new combinations which radically expanded the horizons of the
imagination. By this time the combination of perspective and print culture ushered in a
revolution.

Baroque (1600-1750)

These mannerist experiments revealed increasing ambiguities between the spaces of 1) pictures inside the frames; 2) the frame itself; 3) areas beyond the frames. This led to
such a conscious play with the boundaries between painted and architectural surfaces and
spaces that it became impossible to distinguish them. The manipulation of depicted space
thus became combined in a larger programme involving the manipulation of architectural
and ultimately environmental space. This again transformed the whole nature of pictorial
story-telling. The high mediaeval period began to reduce a basically linear sequence of
incidents into a number of key episodes symbolically arranged. During the proto- and
early Renaissance these incidents were further reduced, interpreted hierarchically, with
some given much more emphasis than others, varied more and increasingly organized in
spatial terms. In the high Renaissance these elements were for a brief period combined in
a coherent spatial harmony. When this harmony was subsequently challenged by the
mannerists and ultimately rejected by baroque artists, the actual content of the stories
gradually lost significance. A method which had promised to give new form to narrative
content, now increasingly replaced content by new spatial forms. Thus Tiepolo's ceilings
of indistinct figures on fluffy clouds prepared the way for the airy ceilings of the
enlightenment.

To understand this paradox of how perspective which, was meant to improve story-telling
also helped to destroy it, we need to focus briefly on three of its distinguishing
characteristics: its power in relating, emphasizing and varying scenes.

**Relating Scenes**

Painters committed to representing a story with many episodes were faced with a
problem of individuating the scenes. Framing them was an obvious step. However,
frames could not give many clues concerning the order in which the scenes were to be
read. Here proto-perspectival elements served to relate scenes while, at the same time,
separating them. Duccio's *Maestà* (Siena, Museo del Duomo, 1288) offers an excellent
case in point. On the back of the altar (Sources, fig. 2), the story begins in the bottom left hand side with Christ’s entry into Jerusalem, moves to the right in an up-down sequence, then returns to the upper left hand side again criss-crossing its way to the far right. Three scenes with Christ and his Apostles (Washing of the Feet, Last Supper and Meeting with Apostles) all share one type of spatial interior with beams of the ceiling converging towards a central axis. Three scenes with Caiphas and the priests occur in an interior with a type of oblique parallel projection. A similar parallel oblique method applied to an awning supported by columns connects scenes with Pontius Pilate in the bottom right and top left. In the Maestà, proto-perspectival elements thus relate separate scenes and help us to follow their sequence.

Giotto used the same technique in the Scrovegni Chapel in Padua (1304-1308), where an oblique view of an open fronted house served for both the Annunciation to St. Anne and the Birth of the Virgin, and where a temple with a niche served as a continuation between three scenes: Ceremony of the Rods, Prayer for the Miracle of the Rods (pl. 7.1) and Marriage of the Virgin. This function of relating separate scenes in a complex narrative helps to explain why a few proto-perspectival elements became stock images which improved empirically, while other architectural elements remained spatially awkward and unconvincing. Piero della Francesca took up these stock images in his On perspective of painting (De prospectiva pingendi, c.1480). Barbaro published them in his Practice of perspective (Pratica della perspettiva, 1568) and thereafter they became familiar elements in the printed texts. Hence the early manuscripts and printed texts (1450-1550) on perspective consolidated and presented in mathematical terms images that the tradition of painting practice had mastered empirically in the two previous centuries. Their initial role was to standardize rather than to innovate. Meanwhile artists explored the practical potentials of perspective. Paolo Uccello in his Profanation of the Host used two vanishing points going in different directions in order both to separate and to relate the two scenes. The same principle is evident in the Munich manuscript of Boccaccio (Hss. Abt. Cod. gall. 6, 53v.) and in the organization of the Teatro Olimpico at Vincenza (cf. Sources, plate 78.1-3).

If scenes with different vanishing points were implicitly related by means of perspective, scenes physically separated from one another were also explicitly related by means of a single vanishing point as in Giotto’s Annunciation in the Scrovegni Chapel in Padua (1304-1306). Masaccio—and Masolino—developed this idea in their Annunciation in San Clemente, and Foppa used it dramatically in his Annunciation in S. Eustorgio. This applied equally to other themes. Parronchi (1964) suggested that Ghiberti used it on the doors of the Baptistery in Florence and has convincingly shown that Masaccio used it to relate The Distribution of the Goods with Saint Peter Curing the Sick in the Brancacci Chapel (Florence, Chiesa del Carmine, 1426-1427). More subtle variants were also possible: spatially analogous scenes could be related without necessarily sharing a single vanishing point as, for example, Piero della Francesca’s Annunciation and Dream of Constantine in the chapel at Arezzo or Raphael’s juxtapositions of sacred and profane scenes in the Stanze of the Vatican.

Aronberg Lavin’s (1990) research into the history of narrative painting brought to light an unusual feature in their arrangement: the narratives did not follow any single, simple sequence from left to right analogous to the sequence of letters on a page. Instead they
criss-crossed, zig-zagged and followed other unexpected patterns. Nor did this always improve with time. A comparison of narratives at Monreale (1182), the Lower Church at Assisi, the Scrovegni Chapel in Padua (1304-1306), Arezzo and the Stanze in the Vatican reveals that the sequences became increasingly non-linear.

Three reasons for this may be suggested. First, whereas art frequently functions as a substitute for literacy in the early middle ages, this changed as literacy became more widespread in the thirteenth and fourteenth centuries and even more so after the advent of printing in the 1450’s, with the spread of vernacular bibles (of which there were 22 in Germany alone before Luther). Artists were increasingly able to take for granted that their viewers had read the biblical stories or at least had heard them read or discussed. This applies even in famous cases such as Assisi. Each of Giotto's frescoes has a Latin inscription as a caption. (Interestingly enough many modern photographs typically cut off these captions so that we learn to see them as pictures in isolation).

Secondly, the situation was complicated through an increased concern with systematic typological and symbolic presentation. In the great rose windows of the thirteenth century (e.g., Chartres, Paris, York), the emphasis was on parallels between the Old and New Testaments with minor references to relevant pagan figures such as the sibyls. In the next centuries this pagan element gained in significance to the point that Raphael’s task in the Stanze became one of finding parallels between Christian and Antique themes: the Church Fathers vs. the School of Athens. In the great cycles it was no longer a question of telling complete stories, but rather one of choosing key episodes in stories which could be balanced by others. Because perspective provided a framework for the organization and comprehension of such scenes, their narrative order often became less significant.

There was yet a third complicating factor. Early proto-perspectival elements functioned partly as frames separating one scene from another. In the Scrovegni Chapel in Padua, Giotto explored how this framing function could be manipulated in order to create ambiguities between real and fictive spaces. Sandström (1963) made a perceptive study of these developments. They are of interest for our purposes because the resulting ambiguities increased the potential for polyvalent readings of the scenes theoretically linked and systematically related: for this reason the Sistine Chapel was more complex than the Scrovegni Chapel.

In the 1470’s artists began to play with relating different viewpoints within a single painting. Piero della Francesca’s Brera Altarpiece (Milan, Brera, 1472-1474) was a case in point. One viewed it frontally to see the context generally and then looked at it from the bottom left in order to recognize that what appeared to be an egg was actually a sphere. Holbein used the same principle in his Ambassadors (London, National Gallery) and Maignan developed it dramatically in his Saint Francis de Paul in S. Trinità in Monte. The development of such anamorphic games (see below pp. 89-90*) further subverted the linear sequence of stories. Sometimes, perspective which developed in the context of narrative, transformed its sequence, and reduced what had been a flowing story into balanced oppositions of key scenes.
Emphasizing Scenes

This was partly because perspective not only related scenes but also emphasized them in particular ways: exaggerating the geometry of the man-made environment, drawing the viewer’s eye into a spatial scene, while reducing the size of individual figures within that scene to a diminutive size. This proved inconvenient for a Christian tradition that focussed on Christ, Mary and various saints. A compromise thus ensued. Individual figures continued to dominate the main panels, while scenes relating to their lives were relegated to the predellas where key scenes were emphasized through perspectival effects. In the Life of the Virgin these included the Presentation in the Temple and Death of the Virgin. In the Life of Christ these were usually the Annunciation, Flagellation and Last Supper. It may be no co-incidence that most of these themes coincided with those typically found in a Book of Hours, the most popular illustrated text of the time.

Manetti’s biography indicates that when Brunelleschi made his first perspectival demonstration, he clearly believed that the viewpoint had to be precisely in line with the central vanishing point of his picture. Elementary textbooks ever since have perpetuated this belief. But it is not quite true. Just as in portraits, where eyes facing the viewer continue to follow one as one moves to the side, so too in perspectival pictures do alleys, corridors and other regular spatial features follow one even when seen from the side. For this reason we can look at perspectival settings and movies from more than one seat (see below pp.**). If Renaissance artists did not discuss the problem, they were clearly aware of it. Kubovy (1986) termed this phenomenon robustness of perspective, and noted how Leonardo realized that his Last Supper would work even though he made its vanishing point at a height where no ordinary observer would view it.

In the Last Supper, perspective emphasized the painting precisely because it could be viewed without undue distortion from anywhere within the refectory of Santa Maria delle Grazie. The same held true for Bramante’s fictive arch in Santa Maria presso San Satiro also in Milan; Tullio Lombardo’s scenes from the Life of St. Mark in the Scuola Grande di San Marco in Venice, and indeed for all Renaissance perspectival pictures with regular receding columns, arches, alleyways etc. The fictive depth involved could be large as in Masolino’s version of Herod’s palace at Castiglione d’Olona or small as in Piero della Francesca’s Brera Altar, but the effects were the same. And like the relating function, the emphasizing function of perspective undermined the continuity of the story, focussing attention on key episodes of a narrative.

Varying Scenes

Professor Brian Stock, in his important book, The Implications of Literacy (1983) noted that: “With shared assumptions the members were free to discuss, to debate or to disagree on other matters, to engage in personal interpretations of the Bible or to some degree in individual meditation and worship”.153 For art, the implications of literacy were equally important. In pre-literate societies a statue of a given god, insomuch it was often the central object that the members of a tribe had in common, defined the communality of a group. Variation was very limited because deviation from the norm could result in lack of recognition. This changed with the advent of literacy. Characteristics of a given god, or the Diety, were known from texts, and because texts now defined what persons knew and had in common, it was no longer necessary for the work of art to establish a sense of
communality. Indeed the challenge arose of creating variants on already well known themes. If this was true for the Bible in general, it was particularly so for key scenes such as the Annunciation. Proto-perspective features augmented this process of variation even before perspective was formally established, as evidenced by Pietro Cavallini’s Annunciation (Rome, Santa Maria in Trastevere) or Ambrogio Lorenzetti’s Annunciation (Siena, Accademia, 1344), generally accepted to be the first painting in which all the lines of the tiles converge to a single vanishing point.

After Alberti’s first treatise (1434), and particularly after the advent of printing in the 1450’s, the process of variation increased in intensity. Some examples, such as the unknown fifteenth century painter in Santa Maria Novella continued to produce rough empirical versions. Fra Angelico made several variants using an open colonnaded space (e.g. Madrid, Prado), thus developing a form used earlier by Nicolo di Pietro Gerini (New Haven, Yale University Collection, 1375); or another with a portico opening into a garden (Florence, San Marco), a theme which Domenico Veneziano (Cambridge, Fitzwilliam) also explored. Sometimes the scene was inside on a regular pavement as in the anonymous Annunciation, (New Haven, Gardner Collection); outside on such a pavement, as in the version by Francesco di Giorgio and Naroccio di Landini (New Haven, Yale Collection), or outside in a green garden as in a version by Filippo Lippi (London, National Gallery), and Leonardo da Vinci’s Annunciation (Florence, Uffizi).

Crivelli, by contrast, developed a spatial example from Bellini’s Sketchbook in his Annunciation (London, National Gallery), which was at once symbolic of Christ’s coming and at the same time a record of a papal grant by Innocent III to the citizens of Ascoli Piceno concerning certain rights of self government which reached the town on the feast of the Annunciation, 25 March 1482. Crivelli thus combined information from a biblical text, a sketchbook and an historical event in his painting. More complex textual sources called for a more complex picture with a spatial arrangement such as that provided by perspective.

A full classification of varying stylistic elements in Renaissance Annunciations would be a large book in itself. Even so, it is instructive to note how every region developed recognizable variants of the same subject. Flemish versions were normally in living rooms (e.g. Robert Campin’s version in the Metropolitian), bedrooms (e.g. Gerard David in the Städelshesches in Frankfurt) or in apses of churches as in Van Eyck’s version (Berlin, Staatliche Museen), which was adapted by the Master of Bruges (Antwerp, Koninklijk Museum voor Schone Kunsten, 1499). In Germany, Annunciations were also frequently in bedrooms as in Dürer’s woodcut (e.g. San Marino, Huntington Library, 1502) and churches as in Grünewald’s Isehnheim Altar (Colmar, Musée d’Unterlinden, 1510-1515), but with very different uses of space. Meanwhile, other Flemish versions combined elements of the living room, bedroom and church interior in a single, rather unlikely space as, for instance, the Annunciation attributed to Henri met de Bles (Cambridge, Fitzwilliam Museum). Variants of this composite spatial arrangement became popular in Spain, as witnessed by Alejo Fernandez’ version (Seville, Museo de Bellas Artes) or in Berreguete’s Annunciation (Burgos, Cartuja de Miraflores).

This practical tradition of using perspective to produce unexpected variants of an already familiar theme continued into the seventeenth century. For instance, nine of Saenredam’s
eighteen surviving construction drawings for his famous interiors involved a single church, St. Bavo, in Haarlem, the exterior of which contemporaries such as Berckheyde also depicted from different points of view (cf. Sources, plates 22-23).

Examples such as the Bayeux Tapestry remind us that already in the eleventh century there were extensive narratives with many scenes. One might have expected that the new links between literacy, biblical texts and proto-perspectival methods would have led directly to a systematic visualization of the story-telling process. Andrews (1988), in an important dissertation, convincingly showed that this was sometimes the case. However, as we have seen, perspective also led particular scenes to be related, emphasized and varied to unexpected degrees. The so-called conquest of reality thus occurred through gradual mastery of a surprisingly small number of basic forms in the context of a few stock scenes. As Veltman (1992) has shown, certain orders of the church were particularly active in the development of this repertoire of stories and scenes. Perspectival effects thus began long before the advent of printing. Nor were these effects necessarily linear. As we have shown they often undermined the strict sequence of the storytelling. Spatial harmony thus began to vie with symbolic harmony, spatial form vied with spatial content, leading to a renewed fascination with light, this time in a secular sense.

Thus the great experiments of Gothic light and story-telling in Chartres, led to the proto-perspectival experiments at Assisi, Padua and Florence, the great perspectival cycles of Renaissance art (e.g. Siena, Florence, Rome, Milan, Venice), and ultimately to the mirrored walls and spacious ceilings of Versailles, where secular candlelight replaced the sacred light of stained glass, and the earlier perspectival stories were replaced by the long perspective of the corridors themselves. As spatial content moved into the environment, it heralded a new age that called itself the Enlightenment.

12. Optics, Mathematics and Science

Returning to the Renaissance, whether the credit be given to Lorenzetti’s Annunciation (pl. 7.3), Uccello’s Annunciation as did Vasari, Masaccio’s Trinity (pl. 8.1) as did Kern, or to Brunelleschi’s panels (pl. 10.1-2), as is the custom today, the origins of linear perspective in a technical sense required much more than a general interest in narrative.

A new attitude to optics as a mathematical science was required. In a sense Brunelleschi, Alberti, Piero della Francesca, Leonardo da Vinci, Guidobaldo del Monte and Desargues (and his popularizer, Bosse) all made mathematical demonstrations of perspective. Yet we need to understand the profundity of changes in the concept of demonstration if we are to appreciate why more than two centuries lay between Brunelleschi’s panels and Desargues’ treatise. For Brunelleschi it sufficed that his representation produced the same effect as the original object. His demonstration lay in showing a physical correspondence. Alberti took a twofold approach. In his On painting he mentioned basic precepts of optics and claimed that these applied. He alluded to mathematical demonstrations which he subsequently recorded in his Elements of painting. These were in fact but a few, simple, isolated examples. Hence Alberti had an optical (visual) and a geometrical demonstration but did not relate the two.
For Piero della Francesca, geometry served as a basis for truth and hence geometry helped to make perspective a tool for certifying vision as well as representation. Piero’s three treatises, *On perspective of painting*, *On the abacus* and *Booklet on the five regular solids* set about the task of relating perspective to a corpus of mathematical texts that included Euclid’s *Optics* and *Elements*, as well as Archimedes. His demonstrations remained predominantly mathematical, yet it is significant that in his *On perspective of painting*, Piero began with visual demonstrations based on surveying experience, suggesting that this was becoming the more valid mode of demonstration. Leonardo da Vinci went one step further. He was not content until he had demonstrated a systematic series both visually and geometrically. As we have shown elsewhere (1986), this led Leonardo to discover the regularity of the inverse size/distance law that Piero had denied. Leonardo effectively demonstrated that a series of experiences related to surveying, coincided with optical experience and could be reproduced with the mathematical projection methods of perspective.

It remained to be shown that the projection methods of surveying and perspective were identical to those of planisphere and astrolabe projection. As will be suggested below, the context for this was several centuries in the making, yet it was not until Commandino (1558) that this was actually demonstrated. The principles of geometry in the context of astronomy were now associated with the origins of perspective. Commandino’s student, Guidobaldo (1600), assumed that geometry was the basis of perspective in painting, architecture and scenography and set out to demonstrate this. For Desargues (1636), the origins of perspective lay partly in his practice of architecture and sundials, partly in geometry. As a result, his demonstration could no longer be in some particular example: it focussed on a general principle that made possible and generated such particular examples. Hence from its earliest proto-perspectival beginnings in the fourteenth century to its codification in the seventeenth century, a basic shift took place in the meaning of perspective.

Scholars have emphasized the interdependence of optics and perspective in these developments. Yet ancient optics clearly did not produce perspective. What changed? As noted elsewhere (*Sources*, p. 142) one answer lay in the scope of optics itself. In Antiquity optics was included in four domains of study: geometry, physics, philosophy and medicine. Euclid’s geometrical *Optics* contained but four propositions on objective questions of measurement in a surveying context and devoted the rest of its fifty-five propositions to subjective, psychological questions of how the eye was deceived. The Middle Ages, particularly in the context of the Arabic tradition, integrated these separate domains to create a coherent field of study and focussed attention on the conditions under which the eye would not be deceived. Optics thus became increasingly a preventative study of conditions in which objective sight was possible. This shift in the definition of optics went hand in hand with a gradual recovery of ancient knowledge, a redefinition of knowledge and a new emphasis on instrumentation all of which played their role in preparing the way for perspective.

In his monumental edition of *The Optics of Ibn Al-Haytham* (known to the West as Alhazen), Sabra (1989), discussed the importance of the Greek tradition (e.g.vol.II, lx) and showed that he used Ptolemy’s *Optics* as a point of departure (II, lx ff.); noting basic differences that more superficial readers continue to overlook. He acknowledged, for
example, that Ptolemy used the term *experimentum* eight times and *experiri* one time in his *Optics* (II, 17), and expanding on a previous article,156 suggested that the astronomical tradition was a likely source of his emphasis on experiment (II, 14-19). An emphasis on experiment became one of the most striking features of the work. Time and again Ibn Al-Haytham spoke unequivocally of an experimenter and experiments (e.g. I, 8, 19, 22, 36, 37, 38, 39, 40, 153) or of the use of specific instruments (e.g. I, 18, 23, 43, 85, 238) and Sabra rightly related this to one of the most distinctive and important features of Ibn al-Haytham’s book (II, lxxxvi): “namely, its adherence to definite forms of argumentation that mainly consist of empirical observations frequently followed by experimental verifications in which geometrical proofs are sometimes employed”. Another crucial feature of his approach was an emphasis on psychology. He (II, liv-lv):

maintained that a theory based on the intromission hypothesis could not qualify as a viable explanation of vision unless it was supplemented and supported by a psychological theory setting out the modes of inference that were necessarily involved in the perception of visible properties other than light and colour....The *Optics* not only introduced a new doctrine but a new methodology for the study of visual perception.

Sabra explored some aspects of the transmission of this text, which Marshall Clagett is said to have described as the most influential single work of the Middle Ages; how it was apparently unknown to most Arab thinkers until the commentary of Kamal al-Din; how the Latin tradition lost Book I of Ptolemy's *Optics* and also omitted the opening three chapters of Book I of Ibn al Haytham's *Optics*; which left Western authors (II, lxxvi-lxxvii): “without a doctrine of light and colour which serves as a basis for the theory of vision in the subsequent chapters of Book I”, and which prompted the development of a metaphysical doctrine of multiplication of species as a basis for later mediaeval optical theory in the Latin West. Ancient optics had limited its concerns mainly to the perception of the physical world. Ibn al Haytham specifically discussed errors in vision that frequently occur when looking at paintings (I. 295):

For painters make their pictures and paintings look like the visible bodies to which they correspond, and by means of flat pictures they represent particular animals, individuals, plants, utensils and other solid objects and their features. For this purpose they make skilful use of colours and drawings, paying particular attention to the points of resemblance. For example, when they make pictures of hairy animals, fuzzy plants, rough surfaced leaves or visibly coarse bodies, they make them look like the visible roughness of the surfaces of those animals or plants or inanimate bodies by means of drawings, outlines and different colours, though the pictures they make are flat and smooth or even polished. They also make pictures of individual people, imitating what is visible in their forms of the outlines of their faces and bodies, their hair, the pores and wrinkles in their skin, and the creases in their clothes; thus they represent the roughness visible in their skin on account of the hair and the pores and the roughness in their clothes due to their creases. Painted pictures will be perceived to be like the forms they represent if those who made them were skilled in the art of painting. Therefore looking [for example] at a picture of a hairy animal painted on a wall or a piece of wood or paper, sight will perceive the [painted] hair as if it were real.
This passage is rather amazing for a culture usually dismissed as iconoclastic in the West as it makes Ibn al Haytham sound like a trompe l’oeil artist, a theme he pursued in the following chapter (I, 309-310), and subsequently when he referred to other illusions of drawn lines in carpentry (I, 318) and to designs which led Sabra to note (II, 20):

The Arabic nuqush (sing. naqsh) is often used in the book to refer to decorative designs, patterns or figures, without specifying whether these are drawn, painted or sculptured- a usage which is widely attested in Arabic literature before and after I. H.'s time. The word may thus be translated as drawings, paintings, mouldings, sculptures or engravings. Reflecting this ambiguity, the Latin translation of the *Optics* employs two terms *picturae* and *sculpturae*.

In other words, while Ibn al-Haytham expanded the scope of visual perception to include designs in general, and only some references to painting, the Mediaeval Latin West focussed attention specifically on painting and sculpture and thus shifted concern to interplay between optics and representation which resulted in the discovery of linear perspective. In discussing the accurate perception of distance, Ibn al Haytham repeatedly referred to ordered and continuous bodies (e.g. I, 153,157,190). He compared frontal and inclined planes (I, 190) and even described lines drawn on the surface of a transparent body (I, 333), all of which again make a Renaissance historian think of Alberti's transparent veil or window, and new links between optics and surveying which led to linear perspective.

Panofsky (1927 etc.) claimed that Euclid's angle axiom, which made apparent size a function of the visual angle, was not challenged until the sixteenth century after the principles of linear perspective had demonstrated the contrary. Ibn al Haytham, in the second or third decade of the eleventh century, specifically stated that (I.178): “It is clear from this experiment that sight perceives the size of an object by means of the magnitude of its distance as well as by estimation by means of the angle, and not by estimation of the angle alone”. Such passages challenge us to rethink many claims made about mediaeval and renaissance optics and representation, even those by major scholars such as Panofsky (cf. II, 100 re: proportion).

It is important to recall that Ibn al-Haytham was much more than an optical commentator. He wrote extensively on mathematics, astronomy and even on cosmology. For example, he wrote a Book on the world or the quadrant, which served as a compendium of theories of celestial motion taken from astrology. This work was noteworthy because it linked optics, astronomy and astrology, combined with instruments in trying to reach “true order and absolute demonstrations”. A version of this manuscript, translated from the Hebrew into Latin by Abraham of Balines in 1510, which used diagrams as “descriptions”, explained that it could serve in resolving a controversy between Giorgio of Cremona and Regiomontanus concerning the distances of things. As will be suggested presently, these links between optics, astronomy, astrology and cosmology became crucial to later developments.

**Optics and the Recovery of Ancient Knowledge**

Ibn al-Haytham’s work can be seen as but one part of a much larger project to recover ancient knowledge. Some awareness of classical sources continued after the fall of Rome
throughout the so-called dark part of the middle ages. The Carolingian revival brought new attention to this heritage which increased through Benedictine scholars such as Gerbert, who later became Pope Sylvester II. The eleventh century reform movement that spread from Cluny transformed this process into an active campaign. In 1141, Peter the Venerable, the Abbot of Cluny, hired Robert Retinensis and Hermann of Dalmatia to translate Arabic works into Latin. Peter wanted to use two of these works, a *Chronicle of the Saracens* and the *Koran*, in his diatribe against infidels.\(^{160}\) Two other works, Ptolemy’s *Planisphere* (c. 1143) and Alkindi’s *On the judgment of the stars*, were intended to serve the translator in composing a treatise on mathematical astronomy and astrology that was to “include in itself the sum of all knowledge.”\(^{161}\) Through the tradition of calculating Christian feasts (*computus*), the Christian West had of course been well aware of the practical importance of mathematics, but the idea that the mathematical sciences could offer a sum of all knowledge was new. There are some references to this translation having been made by Robert’s friend, Hermann of Carinthia (1143)\(^{162}\) and other references to a Robert of Chester (Robert Cestiensis)\(^3\) translating Ptolemy’s *On the composition of the astrolabe* in London (1147). It will be recalled that Abbot Suger's breakthroughs in terms of art and architecture were happening in this same decade of 1140-1150.

Ptolemy was becoming of particular interest. Eugene, the emir of Sicily, translated Ptolemy’s *Optics* (1141)\(^{164}\) from Arabic into Latin. Hermann of Carinthia also translated Ptolemy’s *Optics* (1143) from Arabic into Latin. Eugene, the emir, subsequently helped with an anonymous translation of Ptolemy’s *Almagest* (c.1160) from Greek into Latin\(^{165}\). A desire to find an Arabic version of the *Almagest* for purposes of translation is said to have been Gerard of Cremona’s (d.1187) chief reason for going to Toledo. While there, as part of a corpus of over fifty works, he also translated Tideus’ *On the mirror* and Al-Kindi’s *On vision*\(^{166}\). By the end of the twelfth century Euclid’s *Optics*\(^{167}\), Hero’s *On mirrors* attributed to Euclid\(^{168}\) and the great treatise on *Optics* by Alhazen\(^{169}\) had also been translated into Latin (cf. pl. 9.1).

Around 1261, the Franciscan, Roger Bacon, wrote a preliminary version of his work, *On optics (De perspectiva)*, which cited extensively both classical and arabic authors. In 1265, when Guido Folcodi, became Pope Clement IV, he commissioned his friend, Bacon, to write his major work (*Opus Maius*)\(^{170}\) of which the treatise *On optics* became section five. The incentives for studying optics were increasing rapidly. Peter of Spain (Petrus Hispanus or Hispalensis), having taught at Paris and Siena, wrote a treatise *On diseases of the eye* and moved to Viterbo. In 1268 or 1269 Witelo, who had studied in Paris, also came to Viterbo\(^{171}\). In 1269 or 1270 Siger of Brabant raised the question: “Whether music, perspective and astrology are natural” and decided that they were, noting that “in those things which are tried by abstract principles in geometry, the student of optics (perspectivus) applies to sensible matter.”\(^{172}\) This physical aspect of optical studies had been implicit in Aristotle, but in this context it gained new importance, for the study of physical optics was now linked to its legitimization as a “natural” science.

In 1269, around the same time that Witelo moved to Viterbo, William of Moerbeke also at Viterbo, translated a series of important mathematical and scientific texts including Alhazen’s *On burning mirrors*, Jordanus of Nemore’s *Booklet on the measurement of weights*, Archimedes’ *On volutes which the Greeks call helices*, On centres of gravity, *On
quadrature of the parabola, On the sphere and cylinder along with Eutocius’ commentary, Archimedes’ On cones and spheres, Ptolemy’s Analemma and (Pseudo-) Ptolemy’s On mirrors (i.e. Hero’s Catoptrics). In 1269 a new manuscript of Alhazen’s Optics was also produced. Almost immediately afterwards Witelo used William of Moerbeke’s manuscript of translations (now Vat. Ottob. Lat 1850), when he wrote his great compendium of Optics, dedicated to Moerbeke. Shortly thereafter, Peckham also wrote his two treatises on optics: De perspectiva (1269-1275) and Perspectiva communis (c.1277-1279). It is noteworthy that Moerbeke’s original manuscript (Vat. Ottob. Lat.1850) has appended to it a copy of Pecham’s Optics.

This new concentration on optical treatises in the period 1260-1280 needs to be seen in a larger context of astronomical and mathematical texts. Until the late twelfth century, astronomical discussion had focussed on Ptolemy’s system. Gerard of Cremona’s (d.1187) translation of Aristotle’s On the heavens (De caelo)\(^{173}\) from the Arabic, led scholars to consider Averroes’ commentary thereon which was one of the reasons for the shift towards Averroism in the period 1230-1270, and was almost certainly a major incentive for John of Hollywood (Sacrobosco) to write his treatise On the sphere (c.1220),\(^{174}\) which became a standard textbook for the next centuries. Meanwhile around 1230 Michael Scot produced a Latin translation of Al-Bitruji’s theory of the movement of the planets, which presented a system of homocentric spheres as opposed to Ptolemy’s theory of epicycles and eccentrics.\(^{175}\) New attention to Aristotle’s On the heavens followed with a translation now from the Greek by Grosseteste of Books I-II (1248-1253) and by William of Moerbeke of Books III-IV (c.1260). Meanwhile, Campanus of Novara was translating Euclid’s Elements (1255-1259) and he went on to write treatises on the astrolabe and the quadrant as well as a Theory of the motion of the planets and their instruments, which he dedicated to Pope Urban V.\(^{176}\) Along with Moerbeke and Witelo, Campanus was also active in Viterbo. Hence, Viterbo, which was a centre of papal activity in the 1260’s and 1270’s was directly linked with the recovery of classical and mediaeval texts on optics and the creation of the most important textbooks on optics by Bacon, Witelo and Peckham.

### 13. Instruments

Parallel with these developments was a new interest in the role of instruments in astronomy, optics and surveying. Some scientific instruments had of course been used in antiquity and in the Latin West this continued, probably at a reduced level, from the fourth through the tenth centuries. Then came a change. The individuals mentioned above as responsible for the re-introduction of classical knowledge either via the Arabic or directly from Greek sources, very frequently also played a role in the rise of literature on and construction of early scientific instruments. For instance, Gerbert of Aurillac (c.945-1003) constructed armillary spheres for his lessons in astronomy, made an orologium (either a sundial or an astrolabe) in Magdeburg (994 or 995) and wrote a treatise on geometry with a section on surveying instruments.\(^{177}\) Hermann the Lame (1013-1054), noted as a translator, re-introduced the astrolabe, cylinder and quadrant into the Latin West.\(^{178}\) From this time onwards there was a gradual development of a handful of instruments which provide essential clues concerning a continuity that links the tenth with the sixteenth and seventeenth centuries. In the realm of surveying, the most
important were the quadrant and the rod or Jacob’s staff. In astronomy, the key instruments were the planisphere, astrolabe and equatorium.

**Quadrant**

In the Arabic tradition, the concerns of astronomy became intertwined with those of surveying such that the backs of astronomical astrolabes typically had shadow scales for surveying purposes. The back of Al-Zarqali’s universal astrolabe contained an orthogonal projection of the sphere and a fourth quadrant with a representation of sines that Millas Vallacrosa called the oldest quadrant (*quadrans vetustissimus*). Hermann the Lame introduced a quadrant with a cursor into the West. In the period 1260-1270 Campanus wrote a treatise on the quadrant. Around 1276, William the Englishman, produced a revised instrument that is remembered as the old quadrant (*quadrans vetus*) to distinguish it from the new quadrant (*quadrans novus*), namely, the *Quadrant of Israel* (*Roba’Yisrael*) written in Hebrew by Ibn Tibbon or (Profatius Judaeus), which used as a starting point a treatise of Ibn al-Saffar. This inspired a *Treatise of the new quadrant* (1293) by Peter Philomon of Dacia and a Latin translation attributed to Armengaud, the son of Blaise (1299). An expansion of the work (1301) was in turn translated into Latin by Peter of Saint Olmer (1309) and subsequently led to a revision of the new quadrant by John of Gmunden (1424-1425) who also produced two other versions of quadrants (1425, 1439).

**Rod or Jacob’s Staff**

According to legend, this instrument had been invented by the Old Testament figure, Jacob. In the 1340’s, Levi ben Gerson, at the court of Avignon, systematically explored the uses of this instrument for astronomy and surveying, both in isolation and in combination with other instruments such as the camera obscura. In the first half of the sixteenth century, Apianus and Gemma Frisius greatly developed this instrument for purposes of measuring and representation. The latter sixteenth century saw further refinements in the rod of Orsino Latino (*radio orsino*) written in Hebrew by Ibn Tibbon or (Profatius Judaeus), which used as a starting point a treatise of Ibn al-Saffar. This inspired a *Treatise of the new quadrant* (1293) by Peter Philomon of Dacia and a Latin translation attributed to Armengaud, the son of Blaise (1299). An expansion of the work (1301) was in turn translated into Latin by Peter of Saint Olmer (1309) and subsequently led to a revision of the new quadrant by John of Gmunden (1424-1425) who also produced two other versions of quadrants (1425, 1439).

**Planisphere**

In astronomy, the most basic instrument was the planisphere. As mentioned above, Ptolemy’s treatise thereon was translated by Robert the Englishman (c.1143, possibly identical with references to Robert Cestensis, i.e. Robert of Chester in 1147). Around 1220, Jordanus of Nemore, one of the greatest mechanicians of the Middle Ages, wrote a commentary on this work. Ptolemy had demonstrated that circles are projected as circles only in special cases. Jordanus provided a first general demonstration of this fundamental property of stereographic projection. William of Moerbecke’s translation of Ptolemy’s *Analemma* (c.1269) pointed to connections with sundial projection. These connections continued yet it was not until 1558 that Commandino published his editions of both Ptolemy’s *Planisphere* and *Analemma* and his commentary thereon, making clear their links with perspectival projection, which have recently been republished in the useful editions of Sinisgalli (1992, 1992, 1993). This tradition continued into the next centuries. In 1688 Edmond Halley, of comet fame, dedicated a planisphere of the southern heavens to king Charles II. Nicholas Bion (1652-1733),
constructed a celestial planisphere that reflected the most recent observations made by members of the Academy of Sciences.199

**Astrolabe**

The astrolabe which was a direct development of the principles of the planisphere was perhaps the most widespread instrument at the time and inspired treatises by many of the key individuals concerned with the revival of ancient learning. In addition to Gerbert and Herman the Lame mentioned above, there were Hugh of Saint Victor (d.1141)200; Plato of Tivoli (fl. c.1100-1150)201, Adelard of Bath (c.1142-1146)202 and Raymond of Marseilles (c.1140-1150), whose description became a standard one in university instruction during the next two centuries203.

Around the middle of the thirteenth century, Peter of Spain, one of those active at Viterbo, translated the treatise of Mesahalla (Masha‘allah).204 Later treatises by Bredon (1300-1372)205 and Chaucer (1391) were also based on this version.206 Peter of Maricourt (Petrus Peregrinus), praised by Roger Bacon as the greatest instrument maker of his time,207 wrote a treatise on the astrolabe.208 So too did Campanus of Novara,209 Hagin, who worked in a shop for scientific instruments with Henry Bate of Malines (i.e. Mechelen), made a translation of Ibn Ezra’s work on the astrolabe.210 Moerbeke, working in Viterbo, personally asked Henry Bate of Malines to write his *Magisterial construction of the astrolabe* (1274), designed specifically for the rapid acquisition of astrological data.211 In the fourteenth and fifteenth centuries this tradition continued with further treatises by the anatomist, Guy De Chauliac (1290-1370)212; the mathematician, John of Gmunden (c.1380-1442)213; the astronomer, Peurbach (1423-1461)214, and his student, Regiomontanus. This tradition continued through the sixteenth century with Werner (1516)215, Nunez (c.1540)216, Geminus (1552-1555)217, Danti (1569,1578)218, Clavius (1593,1604) and into the seventeenth century with Vernier (1631)219.

**Universal Astrolabe or Saphea**

A regular astrolabe involved projection principles with respect to a given latitude and required a new face or dial with each significant change in latitude. In the Arabic tradition, Al-Khujandi (d.1000), produced a universal instrument the projections of which could be adjusted for new latitudes220. Sometime before 1078, Al-Zarqali had produced two accounts of the instrument, a major one of 100 chapters, which was known at the courts of Alfonso X but seems to have had little impact on the West, and a minor one with 61 chapters, of which William the Englishman (1200-1300) apparently had indirect knowledge, and which was subsequently transmitted to the West through the translation of Ibn-Tibbon (c.1263) and Moshe Galino before being published in the sixteenth and seventeenth centuries by Schöner (1526), Gemma Frisius, Juan de Rojas and Philippe de la Hire221. Variants on this instrument included the meteoroscope by Werner (1468-1522) designed to solve problems of spherical astronomy. Like the saphea, its first and third quadrants contained stereographic projections of the circles of latitude and longitude while the second and fourth had two different types of sine divisions.222

**Equatorium**

Campanus of Novara, in addition to his writings on the astrolabe and quadrant, described in his *Theory of the planets* an equatorium: an instrument which provided a model of the
motions of the planets\textsuperscript{223}. His contemporary, Henry Bate of Malines also wrote a treatise on the equatorium\textsuperscript{224}. John of Lignères (active in Paris 1320-1335), produced an adaptation of Campanus’ instrument as well as an independent treatise on the equatorium\textsuperscript{225}. A related instrument was described by Richard of Wallingford in his \textit{Treatise of the Albion} (1326-1327). The albion was an equatorium to assist in calculating planetary positions together with ancillary instruments concerned with eclipse calculation, ordinary astrolabe practice and a saphea or universal astrolabe\textsuperscript{226} in the tradition of al-Zarchel. But in contrast to his predecessors, Wallingford set out to construct this instrument in the form of a complex clock complete with planetary trains and tidal dials. Simon Tunsted produced a new version\textsuperscript{227}. In Italy, Wallingford’s younger contemporary, Giovanni De Dondi, inspired by the description of Campanus, also wrote on and then constructed a related equatorium in the form of a great planetary clock (1348-1364)\textsuperscript{228}. This tradition continued through Chaucer (1392)\textsuperscript{229}, Jean Fusoris (1365-1436)\textsuperscript{230}, John of Gmunden (1415-1432)\textsuperscript{231} and through the sixteenth century in the writings of Oronce Finé at Paris\textsuperscript{232} and the models of Jobst Bürgi at Kassel\textsuperscript{233}.

**Instruments and New Links Between Observation and Representation**

Studied in isolation any one of these instruments are of interest only to experts in the history of technology. Considered as a whole these instruments offer important insights for historians of science, culture and philosophy. First, it is evident that the same individuals concerned with the recovery of ancient learning were also those engaged in the rise of scientific instrumentation. Typically one individual wrote on and/or produced more than one instrument. Herman the Lame (1013-1054) considered three: astrolabe, cylindrical sundial and quadrant.\textsuperscript{234} John of Gmunden (1380-1442) considered six: astrolabe, quadrant (in three versions), albion, equatorium, torquetum and cylindrical sundial.\textsuperscript{235} Regiomontanus\textsuperscript{236} and Apianus\textsuperscript{237} produced treatises on different instruments, preparing the way for the more specialized catalogues of Besson, Ramelli, Vasari Jr., Gallucci and Brahe. As a result instruments were no longer limited to an isolated problem in astronomy, optics or physics. They became essential tools of science.

Second, these individuals gradually recognized the universality of the principles involved. Ptolemy’s description of the planisphere focussed on the perspectival projection of a few key points in order to arrive at the circles that represented the tropics of Cancer and Capricorn. Jordanus of Nemore’s commentary established that the projection principles involved were of a more general nature; a fact confirmed by the use of these projections in a whole range of instruments, notably planispheres, astrolabes, universal astrolabes, quadrants, and equatoria. Projection methods became basic to instrument construction as a whole.

Third, the links between theoretical description and practical construction became interdependent. Early manuscripts often contained only verbal descriptions. By the thirteenth century there were frequently very careful diagrams sufficiently detailed to permit a reconstruction based on visual evidence alone. To cite an example from the artistic tradition: Taddeo Gaddi’s representation of a \textit{Virtue} (Baroncelli Chapel, Santa
Croce, Florence, c. 1336-1338), showed an angel holding a spatially rendered armillary sphere. By the sixteenth century the books sometimes contained actual cardboard models of the instruments, the Astronomicon Cesareum of Apianus (1540) being an example par excellence. Hand in hand with this trend towards a visual illustration of the instruments was a trend to represent the projection methods that they entailed.

These new links between theory and practice took many forms. In the last decade of the fourteenth century when Blasius of Parma was teaching optics at Padua, he had his students read Ptolemy’s Planisphere and asked them to demonstrate its principles using candles to project light onto an armillary sphere and observe its projected shadows on the wall. Optics, which had once been a question of philosophical debate or of abstract geometrical diagrams, now required physical demonstrations which could be recorded as representations. Hence aside from their obvious role in the certification of observation, instruments had a deeper role in shifting attention from observation per se to representation of what it was that they were used to observe. It was no longer enough to see accurately: what was seen had to be recorded and demonstrated. That was ultimately what inspired Brunelleschi’s experiments and led eventually to a split in the meaning of optics (perspectiva). The theory of how we see accurately became optics: the practice of how we represent what we see accurately became (linear) perspective. Optics was thought of as the theory of perspective, linear perspective as the practical application. Hence why treatises on linear perspective were frequently called the Practice of perspective, Practical perspective etc., although more conservative authors continued to refer to both the theory of vision and the practice of representation using a single term (perspectiva or optica), and indeed continued to refer to Witelo as a fundamental source even into the seventeenth century.238

14. Re-definition of Knowledge

It is important to recognize, however, that linear perspective was much more than the practical application of optical theory. It came about through a basic shift, first in the organization, and then in the actual definition of knowledge itself.

When William of Moerbeke made his translations of Archimedes, Eutocius, Hero and Ptolemy in 1269, these short works were bound together in a single manuscript. There were practical reasons for this. The treatises and/or fragments were often short and thus were conveniently bound together. This applied equally to the optical texts. In rare cases a compendium of treatises would be almost entirely limited to optics as for example: Ptolemy’s Optics, Bacon’s Optics, Albertus Magnus’ Question on the form resulting in a mirror, Tideus’ On mirrors, Alkindi’s Optics, Malfegyr’s On twilight and Pseudo-Euclid’s On mirrors (Paris, Bibliothèque Nationale, Ms. Lat. 10260). In most cases, however, compendia contained optical treatises along with other subjects such as mechanics and water. For instance, one manuscript (Vatican, Ms. Lat. 2975), contains the above works by Ptolemy, Bacon, Albertus Magnus, Tideus, Malfegyr and two versions of a work On weights and balances attributed to Euclid, Thebit Ibn Qurra’s On weights and measures and Philon’s Pneumatics. There were many combinations of themes. Sometimes it was optics and geometry (e.g. Vatican, Lat. 3102), or optics and astronomy (e.g. Vatican, Lat. 4082) or optics and instruments (e.g. Vatican, Pal. Lat. 1377).
Our concern here is not with the details of these combinations, but rather with the underlying trend that they reveal, whereby optics, which had traditionally been a topic of philosophical debate, became increasingly linked with using mechanical measuring instruments and geometrical demonstrations. Indeed, as the passage cited below (p. 47) from Witelo’s dedication to Moerbeke confirms, the conviction that the heavens were the source of all change on earth introduced new incentives to study astronomy and astrology using optics, or rather optics aided with “instruments for the certification of sight”, to use Witelo’s phrase for astrolabes, quadrants and the like. Hence the development of optics especially from the tenth century onwards goes hand in hand with a rise in the development of scientific instruments, and the resulting knowledge is increasingly made available in a new kind of compendium that links rather than separates various disciplines.

This shift in how knowledge was presented played its role in a more fundamental shift in the definition of knowledge itself. In Mediaeval versions of the Platonic tradition, truth and knowledge had been linked mainly with logic and the other branches of the trivium, namely dialectic and rhetoric. As late as the twelfth century, monks such as Alcher of Clairvaux had distinguished three functions of reason: logic (truth and falsity), ethics (virtues and vices) and physics (experiments which investigate the nature of things). Truth was in a different cubbyhole than experiment and experience.

Meanwhile, a change was underway. It had begun with the revival of learning in the early ninth century, gained momentum in the late tenth century with Gerbert of Aurillac (Pope Sylvester II), and particularly from the second half of the thirteenth century onwards, when these tendencies and isolated initiatives acquired a programmatic character. As part of this change, experimentation and verificati on became linked in the quest for truth. In turn, concepts of truth and knowledge became increasingly linked with the mathematical sciences, and with the rise of scientific instruments outlined above, which served to certify observation and experience. As we have noted, Robert Retensis’ desire to use astronomy and astrology as a means of achieving the sum of all knowledge (c.1143) marked a first formal step in this process. The decision to make the subjects of the quadrivium (arithmetic, geometry, astronomy and music) formally a subdivision of mathematics in the Guide to the candidate (c.1230-1240) at the University of Paris marked another step. Increasing references to truth and instruments, often in combination, with respect to astronomy and optics marked another step.

During this period, while the two new orders of the Church, the Franciscans and the Dominicans, were establishing themselves within the framework of the University of Paris, two major approaches to knowledge emerged. One, championed by the Franciscan, Saint Bonaventure, focussed on inner spiritualism, claiming that knowledge was faith, and prepared the way for the Augustinian revival after 1270 that included Plotinian and neo-Platonic strands. The second, championed by the Dominican, Albertus Magnus, and subsequently by his even more famous student, Thomas Aquinas, emphasized Aristotelianism particularly in the sense of relying on logic and claimed that knowledge was reason. As will be suggested below, the heads of the church were not unaware of the dangers of both extremes and almost certainly saw the study of mathematical sciences, particularly optics, astrology and astronomy as providing a middle ground between these extremes. It may be no co-incidence that in 1268, three years after Bacon...
was commissioned to write the *Greatest work (Opus maius)*, and one year before Gerard of Cremona did his translation, the church organized a debate on the problem of the organization of knowledge (*scientia*), with a special session devoted to the gift of science²⁴⁶. The Franciscan, Robert Grosseteste, had claimed that there were four basic themes worthy of study: preliminary science; experimental science, metaphysics and morals²⁴⁷. His student, Roger Bacon, the protégé of Clement IV at Viterbo, claimed that there were three kinds of knowledge, namely, authority, reason, experience²⁴⁸ and that attention should be focussed on this third kind of knowledge. Hence Bacon emphasized the importance of the greatest scientific instrument maker of his time, Pierre de Maricourt (*Petrus Peregrinus*), whom he termed a master of experiments (*dominus experimentorum*)²⁴⁹. While these were physical experiments, it is important to note that they were not usually systematic as in modern experiments. Peckham, for instance, studied the properties of a light source passing through a triangular aperture. He observed that in some cases the resulting form on a wall beyond the aperture was triangular, whereas at other times it was spherical. It does not seem to have occured to him to change systematically the distance between aperture and wall or the distance of a light source, as Leonardo da Vinci later did²⁵⁰.

It is significant that Peter of Spain at Viterbo, when he became Pope John XXI, was the individual who ordered the investigation into the use of Aristotelianism at Paris which, thanks to a perhaps overzealous bishop, led to the famous condemnation of Aristotelianism in 1277. In short, the new emphasis on mathematical optics in the second half of the thirteenth century marked an effort by the leaders of the Church to redefine the scope of knowledge by shifting attention to the quadrivium in its new mathematical sense in order to avoid the verbal squabbles of the trivium, thus preparing the way for a view that the trivium was trivial.

These trends are all the more striking in light of parallels with the Arabic tradition where students of mathematics began with Euclid’s *Elements* and were then given a series of intermediate works (*mutawaisitat*) such as Autolycus, Aristarchus, Euclid, Apollonius, Archimedes, Hypsicles, Theodosius and Menelaus prior to studying Ptolemy’s *Almagest*. Towards the mid-thirteenth century, Nasir al-Din (1201-1274), wrote a series of these recensions (*tahrir*) on these authors while one of his colleagues, Al-Maghribi (fl.1260-1265), produced new versions of the Greek classics including Euclid’s *Elements*, Apollonius’ *Conics*, Theodosius’ *Spherics* and Menelaus’ *Spherics*. These, especially the recensions, became standard texts in the teaching of mathematics in the very decades that there was an extraordinary surge in mathematical, scientific and optical treatises in the Latin west.

The neo-Platonic tradition, particularly via Pseudo-Dionysius, had developed a metaphysics of light to account for the origins of the universe. Working within this tradition, Robert Grosseteste (1175-1253), wrote *On light or the beginning of forms*, in which he explained that light was “the first corporeal form which some call corporeity,” and used a concept of multiplication of form (species) to account for the propagation of the many from the one²⁵¹. So light was both a universal form and a bearer of all particular form and matter²⁵². The same Grosseteste made geometry and optics basic elements for
an understanding of nature, and made science an essential ingredient for knowledge, claiming that “The usefulness of considering lines, angles and figures is the greatest because it is impossible to understand natural philosophy without these....All the causes of natural effects should be reached by lines, angles and figures; otherwise it is impossible to know their cause”\(^{253}\). These geometrical forms were also discussed in his treatise *On light*. Hence, according to Grosseteste, optics (light) and geometry (lines, angles, figures) were essential to understand the relation of universals and particulars.

It seems that the next generation added another ingredient to this discussion. Ptolemy, in addition to his great works on astronomy, optics, and geography, had written a fundamental work on astrology. The Arabic tradition emphasized the importance of astrology and treated it as a science. When Gerard of Cremona went on his translating campaign, he included works such as Al-Farghani’s *Book on the influences of the science of stars*. In Witelo’s dedication to Moerbeke in his great compendium *On optics*, we learn that there were deeper reasons for these concerns. Astrology and astronomy were now being combined with the metaphysics of light in the optical tradition, in order to explain the shift from the original universal to the particular:

> Now you well understand, sedulous as you are in the study of the being of all things, that the influence of divine powers is, in a wonderful manner, brought to bear upon inferior corporeal things through superior corporeal powers; as you show where you unite in thought the intelligible, derived from its own first principles, to sensible individual things in the manner of a cause and pursue for particular things, particular causes....

> Now verily, of corporeal influences, perceptible light is the mediator, wonderfully assimilating and connecting inferior bodies, which change both form and place, to superior bodies, which are unchanging in substance and only changeable as to their place.

> For light is a diffusion of the higher corporeal forms, moulding, as is the nature of corporeal form, the matter of inferior bodies, and imprinting upon perishable bodies, many in number the forms it brings with it of the divine and indivisible artificers, in themselves unique and indivisible and producing by their union with them ever new specific and individual forms in which results, through the activity of light, the divine contrivance both of the movement of the spheres and of the powers which produce change.\(^{254}\)

This passage is remarkable because it helps to explain why concerns of optics became inextricably linked with those of astrology and astronomy; why these three sciences played a key role in the continuing debates over universals and particulars which had dominated discussions of the late twelfth and early thirteenth centuries\(^{255}\) and why writings and later publications on astrology continued to increase in the next centuries. Astrology was much more than a source of horoscopes. Along with optics, geometry and astronomy, it was one of the keys for understanding the mystery of creation: a basis for cosmology. Since astrology was seen as a basis of health, this combination of disciplines therefore became crucial for medicine as well as being fundamental to philosophy, science and theology. In the short term, a ‘negative’ consequence was an ongoing interdependence between metaphysical and physical optics such that there was no immediate separation between inner subjective and outer objective optics. In the long
term, a positive consequence was that it prepared the way for Kepler’s *Commentary on Witelo concerning the astronomical part of optics* where precisely this distinction was brought into focus.

It is no coincidence, therefore, that the four greatest names in fourteenth century optics were also involved with geometry, astronomy, astrology as well as cosmology, namely, Dominicus da Chivasso, Nicolas Oresme, Henry of Langenstein and Blasius of Parma. Dominicus da Chivasso (Clavasio or Clivaxo), a student of Buridan at Paris, was active in the second half of the century as a medical doctor, astronomer, physicist, geometer and perspectivist (*perspectivus*). In addition to his *Questions on optics*, he wrote a treatise on geometry and a commentary on Aristotle’s *On the heavens* (*De coelo*). This work, entitled *Questions on the heavens and the world*, became linked with other treatises on physics by Bradwardine, Burley, Swineshead, Jordanus of Nemore and Oresme (e.g. Vatican, Vat. Lat. 2185). Oresme wrote on many aspects of optics, astronomy and cosmology including a *Treatise on the incommensurability of celestial motions* (Vat Lat 4082). His student, Henry of Langenstein, besides his *Questions on perspective*, wrote on geometry and various aspects of astrology: *On the characteristics of causes*, *On the reduction of effects* and a *Treatise against the conjunctive astrologers*. Blasius of Parma, besides writing on optics, was active in natural philosophy, mathematics, astronomy, and astrology. He explicitly claimed that “astrology can do nothing without optics (*perspectiva*)”, and wrote, for instance, *Geometrical demonstrations concerning the theory of the planets* (Vat. Lat. 3379). Vescozini (1965) has been prophetic in emphasizing the importance of these nexes, except that where she emphasized philosophy, we would insist more on the interdependence of theology, science and philosophy.

Other factors contributed to this growing interdependence of disciplines. In the twelfth century, Averroes (1126-1198), active at Cordoba and Seville, had criticized Aristotle, claiming that “The model that has been developed in the times in which we live accords with the computations not with existence” and that Ptolemy’s explanation was “mathematical and not physical”. In his quest to create an explanation that corresponded with physical experience, Averroes wrote a now lost treatise on the regular solids and which of them do or do not fill spaces completely. This began a serious controversy which provoked commentary by Bacon, and prompted Regiomontanus to write his now lost treatise on the regular solids. A few decades later Piero della Francesca produced his booklet *On the five regular solids*. Maurolycus, one of the greatest mathematicians of the sixteenth century, knew of, but had not seen Regiomontanus’ manuscript when he wrote his treatise *On the five solids, which are popularly called regular, namely which of them fill a space and which do not, against Averroes, the commentator of Aristotle*, in 1529 (with emendations in 1535). Renaissance authors considered Piero’s treatise on the solids to be a perspective treatise, and hence it is not surprising that the regular solids became an important theme in perspective treatises (cf. *Sources*, pp. 90-91). Seen in this larger context whereby astronomy, astrology, and optics (*perspectiva*) were linked with cosmology, one of the major incentives that led to the spatial initiatives of scientific perspective becomes clear: a quest not just to measure and represent but also to explain the structure of the universe. Hence, it is no coincidence that a number of the early individuals concerned with
perspective were among the leading figures of early modern science and mathematics: Piero della Francesca, Leonardo da Vinci, Pacioli, Commandino, Benedetti, Guidobaldo del Monte, Galileo, Descartes, Leibniz and Newton.

Meanwhile, the fourteenth century also brought a gradual shift that emanated from the University of Oxford through Bradwardine (1290-1349), who set out to destroy the union between faith and reason, which led to mathematics, astronomy and optics being freed from theological suppositions. At the University of Paris, Buridan (1300-1352), developed a new theory which relied on calculations and promised to save the phenomena using a universal formula. This he applied to so-called natural movements including the accelerated fall of weights and the trajectories of celestial bodies. His younger contemporary, Nicole Oresme (1325-1382), argued that space and time are divisible to infinity and that their continuity extends to all the forms of change such that it is possible to measure geometrically the variations in intensity in same way that we measure spatial change. In order to facilitate this measurement, Oresme conceived of two coordinate axes corresponding to intension and extension, a graphic equivalent, as it were, to the hypothesis of impetus (impétuosité or vertu motive). Oresme also discussed the image of the cosmos as a clock. Marsilius of Padua (d. 1336/1343) defended Oresme’s theory of intension of forms and represented graphically the heating of a body using a series of diagonals that parted from a right angle. Albert of Saxony (1325-1352) pursued the interests of Bradwardine, Buridan and Oresme in astronomy, optics and physics. Albert studied quadrature of the circle which, it has been argued, prepared the way for analysis of the continuous and of incommensurability. He also distinguished the geometric centre of the earth from the mechanical centre of the celestial motions.

These developments attest to a gradual shift in the thirteenth and fourteenth centuries whereby problems of astronomy, optics and physics were being analysed geometrically as well as mechanically and both methods were being compared with one another. Optics was no longer simply a trivial matter of philosophical debate. Its principles were studied physically and recorded instrumentally. Geometrical rays were no longer just abstract mathematical principles to be discussed verbally. They were practical phenomena to be recorded and represented visually and instrumentally. In Roger Bacon’s terms, knowledge as authority and reason, was being replaced by knowledge as experience. Is it mere co-incidence that this shift took place in the generation before Dante changed the course of literature and Giotto changed the course of art? These new trends were more than new ways of looking at the world. They reflected a re-definition of what it means to know.

By today’s standards, this shift in the definition of knowledge was very slow. For if the 1260’s marked a first conscious articulation of that goal, the first serious repercussions in curriculum could be seen to begin with John of Gmunden’s chair of astronomy at Vienna in the early 1400’s which combined the use of practical instruments and theoretical texts. Meanwhile, Florence, which became the artistic centre of the Renaissance in the early fifteenth century and saw the first technical demonstrations of perspective did not have the appropriate combinations of theory and practice with respect to scientific perspective found in other centres such as Padua and Vienna. From Ghiberti’s Commentary it is clear that the Florentines were aware of the mediaeval optical tradition. They knew Alhazen in
translation and studied Bacon, Witelo and Peckham. So they were well aware of experiments with camera obscuras. But Brunelleschi, as an architect, was concerned primarily with practice and there is no evidence of his trying to deal with or write about perspectival theory. His panels made some time between 1415 and 1425 remained strictly practical demonstrations.

Leon Battista Alberti’s *On Painting*, the first treatise to discuss perspective did so in terms of grammar, dialectic and rhetoric rather than geometry, arithmetic, music and astronomy, i.e. focussing on the trivium rather than the quadrivium and thus emphasizing the concept of (hi-)story (*istoria*), which helps to explain the absence of technical diagrams in the early manuscripts. Nonetheless, as a universal man of the Renaissance, Alberti was aware of two methods or rather two ways of demonstrating the principles of perspective. In *On Painting* he described a demonstration based on surveying practice, which he may well have learned in Padua (see *Sources*, p.43-44). In his *Elements of Painting*, by contrast, Alberti linked perspective with Euclid's *Elements*, i.e. with geometry and more precisely with geometrical proportion. In the next generation Filarete alluded to both of these methods but as a pragmatic architect he added nothing substantial to the discussions.

Piero della Francesca made two major contributions. First, he set out to establish that both of these methods had their foundations in Euclidean geometry. Having discussed surveying principles in the introduction to his *On Perspective of Painting*, he devoted books one and two to the method of geometrical proportion which Alberti had discussed in his *Elements of Painting*. In book three of *On Perspective of Painting*, Piero turned to the alternative method entailing a perspectival window and strings, which history has remembered as the legitimate construction.

Piero second contribution was to expand the Florentine and Tuscan context of painter's perspective to the larger context of mediaeval optics (*perspectiva*). As noted earlier (*Sources*, p. 90), Piero's two other treatises included a *Book of the Abacus* and a *Booklet of the Five Regular Solids*. Both of these dealt with the construction and representation as well as the measurement of the five regular solids. Both of these books were viewed by sixteenth century authors as perspective texts. Now as we have noted, ever since the time of Averroes, the regular solids had become of central importance in debates concerning the structure of the heavens. So perspective was no longer just about painting practice. It extended to questions of astronomy and cosmology. Perspective was no longer merely a theme for how to do it books. It was concerned with questions of why: with causes. All of which helps to explain why Piero's student, Luca Pacioli linked perspective with both astronomy and cosmology in his treatise on *Divine Proportion* (1496-1499, printed 1509) or why perspective became a gateway to Leonardo's scientific method.

The links with measurement made explicit by Piero, were broached in more practical terms by Francesco di Giorgio Martini and developed by Leonardo da Vinci. Dürer included this approach to perspective in his *Instruction in Measurement* (1525). Rodler (1531), went further and made perspective synonymous with measurement. Even so it was not until the 1550’s until the scientific dimensions of perspective became a programmatic part of teaching through the efforts of the Jesuits. By 1556 the Jesuits had established themselves in twenty Italian cities, including Rome, Naples, Florence, Siena,
Bologna, Padua and Venice. By 1557, preliminary attempts at a Jesuit curriculum had begun, although the first formal plan (ratio studiorum) was not established until 1586.

Jesuit interest in compendia of optical texts, mentioned above, is, for instance, found in a fifteenth century manuscript that was owned by the Jesuits in the sixteenth century (Rome, Biblioteca Nazionale, Ms. Gesuitici 2546 419), which contains Ptolemy’s Optics, Euclid’s On Mirrors, and Albertus Magnus’ On the forms that appear in mirrors.

A closely related Vatican manuscript of 1554 (Vat. Lat. 2975) also contains Ptolemy’s Optics, Bacon’s Optics, Euclid’s On Mirrors, Tideus’ On the quality of that which is seen in mirrors and their deceptions and Albertus Magnus’ On the forms that appear in mirrors. Such compendia reflected a renewed interest in ancient and mediaeval treatises in optics and instruments in the 1550’s. For example, another manuscript in the same library (Vat. Barb Lat. 304), contains a fragment of Ptolemy’s Analemma (fol. 160-162r); lists of Greek manuscripts in the library at Carpi including On optical hypotheses and Heliodorus of Larissa’s Optics (f. 163r); mention that one needs good instruments and good compasses if one is to draw properly (202r); a list of scientific and mathematical books including the Planisphere of Federico [Commandino]; a section On practical perspective (211-212v), explaining that it is derived from both geometry and optics, referring to an instrument for perspective produced by Witelo; mention of Barozzi il Vignola’s work on sundials (204r); drafts of a first lecture on sundials, dated 1558 (205r); a third, fourth and fifth lecture on the analemma and sundials (213v-221v) and various lists of books. We are told that M. Federico [Commandino] has a large Ptolemy and the Planisphere of Ptolemy and the astrolabe (254v). Reference is made to the Optics of Peckham, Euclid, and Ptolemy (264r). There is a mention of a First lecture on optics (perspectiva) (264r); to treatises on perspective by Piero della Francesca (270r) and Master Federico [Commandino] (271r); to Maurolycus being in touch with Master Jeronomo [Cardan?] concerning Master Federico’s problem of proportional division of lines on 8 October 1557, evidently one of the contexts for the development of the proportional compass or sector.

Towards the end of the manuscript there is a reading list for optics (perspectiva), namely: Ptolemy, Euclid, Alhazen, Witelo, the commentary on the Common perspective of Butius, the canons of the instrument of Witelo and Federico [Commandino’s] Practical perspective. Hence, Commandino’s interest in perspective and its relation to Ptolemy’s Planisphere and Analemma was part of a larger trend to understand the theory and practice of optics and perspective. Indeed there is evidence that it was connected directly with a new curriculum for the mathematical sciences that was being developed by the Jesuits in these very years.

We know that one of the earliest study lists of the Jesuits included the sphere, geography, theory of the planets, the astrolabe and optics (perspectiva). In the earliest cases Peckham and Witelo were used. In later outlines this became part of a more comprehensive plan:

And starting at the beginning, dialectics, three months before the first year, it will be well that they hear practical arithmetic for the months of August, September and October; and at the beginning of logic they hear the first three books of Euclid, which they will read in less than four months; and they will also hear the
sphere which will last another four months and geography, which will last another three or four months and thus the second year will be completed. In the third year [they will hear] the theory of the planets for a space of four months and the astrolabe for another four [months], and optics (perspectiva) for the other four [months]. And in this manner they will always hear two lectures, one in the morning in the first hour and the other after eating...and that each person has a compass and ruler with which they can exercise on some figures, and that four or five months after they have begun the course they can have the fourth, fifth and eleventh book of Euclid and go on to the theories and to introduce the tables and if they have time that they hear something about sundials, either the ring, or the quadrant or the radius or the ecclesiastical computus or the solid sphere.

This became one of a series of new programmes which formalized the interplay between theoretical study of texts and practical use of instruments for observing, recording and representing the physical world that had been emerging since the eleventh century and was given a new impetus at Viterbo in the 1260’s. A manuscript probably written in the 1570’s or 1580’s by Clavius, who subsequently became head of the Jesuits, outlined:

A way in which the mathematical disciplines can be promoted in the schools of the Society of Jesus.

Now since among the experts it is held that in physics nothing can be perceived without these [mathematical sciences], especially with respect to that which pertains to that domain, where one deals with the number and motion of the heavenly bodies, with the number of the intelligences, with the effects of the stars, which depend on the various conjunctions, oppositions and the rest of the distances amongst them; with the infinite division of continuous quantity; with the ebb and flow of the ocean; with comets, rainbows, haloes, and other meteorological matters; with the proportion of motions, qualities, actions, passions and reactions etc. of which the calculators speak.
Once this context is understood, we can explain not only Commandino’s interest in planispheres and perspective in the late 1550’s, but also why religious authors such Daniele Barbaro (1568) and Egnazio Danti (1583) produced the first major Italian publications on perspective in this period. Danti’s and Stevin’s quotes about perspective authors trying to understand the causes of things (see above p. 2) also take on new significance, all the more so when we recall that at the time the young Galileo, who was soon to work with Cigoli on perspective, was beginning his studies. Moreover, given the concerns of Clavius and the Jesuits with problems such as ebb and flow of the oceans as one of the mathematical applications of physics, and Galileo’s early studies with the Jesuits, it is hardly surprising that the underlying purpose of Galileo’s great work on The two world systems should have been ebb and flow of the oceans. The cosmological picture which Galileo attempted was taken further in the next generation in Paris, which became a world centre of perspective as well as mathematics and science. Thus the links between optics, perspective and new approaches to knowledge which had begun in the mediaeval period continued into and throughout the seventeenth century.

15. Politics

These developments are better understood if seen in their political context. From the time of Charlemagne (crowned 800), and increasingly from the eleventh century, onwards there were tensions between church (pope) and state (emperor). In its simplest form this amounted to tensions between South (Rome) and North. This evolved into struggles between papal Guelphs who favoured banking, business and commerce, versus imperial Ghibellines who favoured artisan work. These groups gained further allies. The Guelphs aligned themselves with the Anjou line, which became linked with England through the Anjou-Plantagenet connection (1154-1399). In Northern Germany, the Guelphs were called Welfs, and hence were linked with the Staufers. The Staufers and Anjou lines became linked, while the Ghibellines allied themselves with the Capetan line. In Southern Germany, the Ghibellines were linked with the Hohenstaufen family. (Indeed the name, Ghibelline, was said to be derived from the family’s ancestral seat at Waiblingen).

As we have noted France was one of the first centres of systematic attempts at the recuperation of classical mathematical and scientific knowledge. Spain followed soon after. Through the efforts of the Franciscan, Grosseteste, and others, the work of the Toledan translators became known at Oxford and elsewhere in England. The Anjou-Plantagenet connection brought further co-ordination of French and English efforts in the recuperation of ancient knowledge. In the period 1220-1250, the Emperor Frederick II’s alternating co-operation with the pope meant that initiatives in Germany, Northern Italy and the Kingdom of Sicily (which included Southern Italy) became integrated in the recuperation of ancient knowledge. After 1265, when the pope gave Southern Italy and Sicily to Charles of Anjou these French, English, Spanish, and German initiatives became further linked with Sicilian efforts in the translation of ancient sources of knowledge.

Indeed there are striking ways in which the new developments in Italy can be seen in terms of new Guelph-Anjou power and new links with France. In the latter twelfth century, Saint Francis, is said to have received his name because he was born on one of his father’s business trips to France. The Franciscans, particularly through their English
branch (Grosseteste, Bacon, Peckham), devoted new attention to study of the natural world using the mathematical sciences. The period 1254-1268, which saw a decline of the Hohenstaufens, brought a dramatic rise in influence of the Guelphs through new links between the pope and Charles of Anjou (1265). With the death of Manfred at the Battle of Benevento (1266) and the defeat of Conrad in the battle of Tagliacozzo (1268), Guelph influence spread to other cultural centres such as Siena. The same decade brought new links between Viterbo and Paris and the first examples of persons such as Brunetto Latini, who travelled from Italy to France, came under the influence of the Provençal troubadour poets and then returned to Italy where they became major literary figures. Hence it is no coincidence that Assisi, Siena, Florence, which were under Guelph rule and had French connections, became the key cities in the development of proto- and linear-perspective.

The expansion of the Papal Estates particularly in the second half of the thirteenth century, meant that there was a strip of land linking Rome, Viterbo, Orvieto, and Ancona; and closely bordering on cities such as Perugia and Assisi. As White (1957), has noted (see below p. 58*), it was precisely in this period that knowledge of the great Roman narrative fresco cycles travelled North to these cities. In the next generation individuals such as Cimabue worked in both Guelph (Florence) and Ghibelline (Arezzo) territories thus eroding the significance of these political factions with respect to cultural development.

By the early fourteenth century, the Church’s ploy of using French connections to undermine the power of the Holy Roman Emperor, had unforeseen consequences when Clemens V (1305-1314) became the first in a line of French popes, thus manifesting the dependency of the curia on France. By 1309, the papal court moved to Avignon and it was here that Simone Martini went in the 1340’s, thus initiating new interplay between French and Sienese art. This French connection seems to have been important for a new emphasis on narrative (see below p. 106*), which was another of the stimuli in the development of perspective.

16. Conclusions

We have shown that the question of the origins of perspective has a complex history. When it was first discovered in the fifteenth century there was minimal concern with how it began. From the sixteenth through the nineteenth centuries credit was typically given to a profession such as architecture or an individual. In the latter nineteenth century a new attention to sources made it necessary to find more detailed explanations. The mode of explanation also changed to include a philosophical framework. It was assumed that a change at the abstract level of ideas in terms of world view and concepts of infinity had inspired changes in the representation of space at the concrete level of painting practice. Artists were seen as precursors to scientists. This trend continued into the twentieth century whereby artists such Brunelleschi gained an increasingly symbolic role.

In the twentieth century, discipline centred approaches came to dominate explanations. Some art historians such as Panofsky continued an awareness of the philosophical tradition: most returned to explanations involving specific disciplines, notably optics, geography and astronomy. In the nineteenth century, art historians had been fascinated by possible connections between phylogenetic and ontogenetic development (cf. below pp.
Ironically, when they abandoned this approach in the twentieth century, it was adopted by psychologists, who used it for their version of historical treatment. Marxists offered a fascinating social explanation which as we have shown bore little correspondence with historical evidence. It is noteworthy that historians of mathematics, who remained very interested in perspective as a key to understanding the origins of descriptive geometry, devoted minimal attention to the origins of perspective as a topic in its own right. Similarly historians of science continued to show some interest in the history of optics but tended to dismiss perspective as merely artistic.

In reassessing these explanations we distinguished clearly between different stages of development. The conditions for Giotto to produce a proto-perspectival representation of space in Assisi or Padua were different from those involving partial or systematic mathematical demonstrations. Because these developments involved a whole range of media they necessarily entailed a whole range of professions. Hence, the trend of scholarship in the past century which identified a single individual as if perspective were a simple event was misleading. This led us to look at a series of factors including the development of narrative on the artistic side. Here we found that Renaissance Italian developments owed much to innovations in Gothic art and literature in France. In trying to outline key shifts in the representation of space from Gothic, through Renaissance, to Baroque art, we discovered that perspective, which initially set out to enhance the effects of pictorial narrative also undermined it. To understand this paradox, there was an excursus on three distinguishing characteristics of perspective: how perspective helps in relating, emphasizing and varying scenes.

To understand the mathematical and scientific origins of perspective, we explored how developments in optics related to shifts in the meaning of knowledge during the thirteenth and fourteenth centuries. We suggested that the history of instruments, which historians of technology had typically treated in terms of particular objects, offered a more universal context for the spread of planispheric projection techniques with a whole series of applications. In these developments astronomy and surveying played a seminal role.

Scholars such as Crombie (1953) claimed that a fundamental quest for truth, which was originally developed in Greece, was recovered by Grosseteste and his followers in the thirteenth century. According to Crombie, it was Grosseteste who introduced terms such as experiment and observation, which were to prove crucial for the later development of Renaissance science. He claimed that the use of these terms remained constant for the next centuries and that there was therefore a continuity via texts and print culture linking Fibonacci and Grosseteste in the thirteenth with Galileo in the seventeenth century. There is certainly some truth to this. Persons kept quoting Aristotle and Plato, kept depending on Euclidean geometry and made similar philosophical claims rhetorically. A number of the Oxford Franciscan physicists of the thirteenth century and their successors in the fourteenth century, the calculators (e.g. Swineshead), were published in the late fifteenth century and became part of the Jesuit curriculum in the latter sixteenth century.

Even so, as we have shown, there were also basic factors that changed such as a new mathematical approach to optics, fresh links between mathematics and knowledge, the development of scientific instruments to record nature and the rise of perspective both to
record and to reproduce records of nature. These developments created bridges between abstract mathematics, concrete instruments and objects, thus changing science from an intellectual exercise to a process involving physical practice as well as mental theory. This process was slow, cumulative and incontrovertible, leading from Fibonacci (in the thirteenth century) through Regiomontanus (in the fifteenth) to Leonardo da Vinci (in the sixteenth) and Galileo (in the seventeenth century), such that Galileo’s world also seems fundamentally different from that of the middle ages. We suggested that to understand this process requires attention to basic shifts in knowledge both inside and outside the universities, as well as to the changing political context.

This suggests a picture that is considerably richer than that offered by earlier scholars (Ivins, McLuhan, Panofsky, Eisenstein, Gombrich, Crombie). We have shown that the so-called conquest of reality depended largely on painting practice. The contents of perspectival treatises introduced various independent themes: regular solids, semi-regular bodies; other objects such as lutes, chairs and stairs as well as buildings and gardens. The combination of these themes created a new interplay of printed images, painted and actual objects, resulting in new horizons of the imagination and plays between real and fictive space. Thus by the latter sixteenth century the traditions of perspectival practice in painting and perspectival theory in printed texts had begun to interact in revolutionary ways that affected not only spatial representations of images but transformed the very layout of the environment, first on a small scale with piazzas such as the Capitoline, ultimately on an enormous scale as at Vaux le Vicomte, where villages were razed to raise a view, and Versailles, where an horizon was altered to suit a sun king.

Eisenstein’s book argued for a sudden revolution in printing, making the 1480’s a turning point, in explaining the rise of perspective and in settling fluid boundaries between Mediaeval and Renaissance culture. We have shown that the processes of innovation that we remember as the Renaissance were both slower and more cumulative than generally assumed; that the fundamental implications of printing emerged only gradually in the course of three centuries and that printing in isolation was ill suited to settle boundary disputes in the wars of periodization. We suggested that perspective offered a better framework for understanding key aspects of this transition period and that perspective involved the history of art, science and mathematics, entailing the rise of new orders in the church as well as more general changes in politics. It was part of a fundamental shift not just in the presentation of knowledge but in its re-definition, which owed much to a combination of a Franciscan emphasis on nature with both Cluniac and later Dominican concerns to recover a corpus of Ancient knowledge and to arrive at a new level of encyclopaedic insight. It entailed contributions by Benedictines such as Gerbert and Maurolyco; propagation by Jesuits such as Clavius, and explanation by learned Dominicans such as Danti.

Giesecke (1991) argued that the rise of printing led to a new visual and ultimately perspectival approach to description that was intimately connected with a shift in the concept of knowledge and the emergence of a new sense of truth. While fully accepting the general thrust of these findings, we are now, in retrospect, able to assert that the origins of this shift can be traced clearly to at least the year thousand although it was not until the mid thirteenth century that the Dominican recuperation of ancient knowledge
and the new Franciscan approaches to science, history and experience/experiment introduced the final ingredients for this new approach.

In the fields of economic and political history, Braudel and other members of the Annales school have argued that we need to understand change in terms of long term movements (la longue durée). Our study would suggest that this phenomenon applies equally in the history of art, of science and culture as a whole. Where others would have us believe that the origins of perspective lie in some spontaneous, sudden discovery made by a Brunelleschi, an Alberti or the like, we would stress the need to understand a complex shift that was centuries in the making, the consequences of which have taken centuries to understand and indeed the complexities of which are even today not yet adequately appreciated.

Hence, perspective is much more than a painting technique made possible through combinations of surveying and optics that made it practical on a terrestrial plane. As we have shown, its origins were as much in the heavens as on earth, in new combinations of instruments being applied to optics, astronomy, and astrology. While the planisphere became a symbol for these connections, it was actually only one member of a complex family of instruments that established projection methods as a universal principle. All the ingredients had classical precedents. Some Ancients had sought for truth and to understand causes. Some had used instruments. What was different about the developments in the latter Middle Ages was that these initiatives became increasingly programmatic. The accumulation of knowledge changed from the individual efforts of a brilliant Greek or Roman philosopher, to the combined concerns of orders of the Church with teams of scholars in thousands of monasteries across Europe. This made their efforts much more than a passing fashion of making realistic images.

The re-definition of knowledge in the period 1000-1600 entailed a new commitment to instrumental observation, recording and representation, to establish new standards of certification and truth, and for this reason it became so integrally connected with philosophy, science and theology. When Panofsky emphasized that the rise of linear perspective was linked with changes in a world view, he was both wrong and right. He was wrong to assume that perspective was merely a physical consequence and manifestation of a new abstract concept of infinity. He was right, in senses he did not suspect, because perspective was not just a means of recording the effects of philosophy. It provided philosophy and ultimately both science and theology new methods for understanding causes. To repeat the words of Danti cited earlier (p. 2) the concern was:

> with the most scientific who are not content in simply knowing how to operate well and knowing that a thing is thus, but in addition to know its causes. Hence I have endeavoured to demonstrate all the principal parts of this geometrically.²⁸¹

Paradoxically, a serious history of this quest has yet to be written. On the technical side it will require a systematic study of projection methods in all the treatises on instruments; comparison between verbal descriptions, diagrams and the evidence of the extant instruments in museums and private collections. Second, it will require a systematic study of the workshops that made instruments and the growing network of links between them. Third, it will be necessary to do a history of compendia, which treatises got linked with which, in order to arrive at a serious appreciation of changing intellectual horizons.
and understand how connections between topics changed from general to specific. Fourth, we need a richer history of transmission of manuscripts, books, instruments and combinations; which amounts to a new kind of history of institutions. It is one thing that an idea existed. Its availability and its accessibility in combination with other ideas is quite another thing. The cumulative strength of the West has been precisely in its strength of accumulation of ideas. Just as new media such as manuscripts and printing played a role in making possible the Renaissance, computers will play a key role in making possible these new approaches to study of the the past, which will in turn transform our future prospects. Hence, if too much ink has been wasted in search of an event by asking when it all began and focussing on a Brunelleschi, Alberti or Piero, our analysis has indicated that many aspects of the multi-media history of perspective have yet to be studied in detail.
II. HISTORY

1. Introduction

Our knowledge of the history of perspective derives from at least five kinds of sources, notably, histories of art and general histories; histories of mathematics; the treatises themselves; encyclopaedias and bibliographies. Since most of the material is found in the first category, for the sake of convenience separate headings are provided for different chronological periods. The other categories, which vary enormously in terms of both the quantity and quality of information, and are mainly of interest with respect to earlier centuries, will also be treated separately.

2. Histories of Art and General Histories

Effectively nothing has been written on the possible spatial methods of prehistoric cultures, it being generally assumed that systematic spatial methods first emerged in Egypt. These writings will be considered very briefly. The great majority of those who have written on the early history of perspective fall into two main schools: one assumes that perspective began in Antiquity and was rediscovered during the Renaissance; a second claims that perspective did not begin until the late Middle Ages or the Renaissance.

Prehistory (4000-1000 B.C.)

Schäfer's (1919) classic *Principles of Egyptian Art* in fact offered a survey of all pre-Greek art. Schäfer was very (337): "clear that the expressive imprint which a work of art bears is not based on the use of frontal images or perspective". By way of context he explored essential characteristics of Egyptian art and the concept of art and creativity that it entailed. Having described their treatment of isolated objects he examined their methods of rendering spatial distribution: including loose assembly without indication of depth, maps, association of ideas, the use of base lines and ground lines as registers, objects depicted on or above one another without overlapping, figures juxtaposed without overlapping and with overlapping; rising forms which indicate distance without recourse to overlapping. Schäfer noted that there were parallels between the rise of the optical field with distance in art and new terms for this in language. He examined various techniques they used in the rendering of nature such as apparent passing next to and action beside an object, turns, looking and moving out of and into the picture, splitting of groups, the image in correspondence with the position of the viewer and the depiction of trees around open spaces. In all this he made comparisons between ancient Egyptian drawings and modern children's drawings.

With respect to perspective Schäfer began with perspective-like exceptions to the fundamental rule of depiction based on frontal images, namely, bird flight and related motifs, sunshades, bees, arm-rings, fish-traps, scaling ladders on wheels, back views of serving girls and shields. This led to a discussion of how the human body was rendered in two dimensions to which he claimed the basic principles of rendering nature in three dimensions were related. By way of explanation Lange (1899) had developed what he believed was a "law of frontality". This Schäfer revised with a rule of directional straightness (316):

Three-dimensional representations of human beings, animals and other objects that are symmetrical round an axis, which are produced by all peoples and
individuals who have not been influenced directly or indirectly by Greek fifth-century art, conform to the rule of directional straightness. This rule results from the opposition between the method of representation based on frontal images and the structure of the objects serving as originals: a plane is imagined as a starting point and the other principal planes of the torso and limbs adapt to it to form an intersection of planes at right angles.

Schäfer then turned to technical procedures of Egyptian art. He noted how lines and dots were used in the composition of two-dimensional works in the Old Kingdom and that, in the New Kingdom, these were replaced by squared grids which, like the frameworks, fixed the proportions of the body.

In a new edition of Schäfer’s work, Brunner-Traut (1974), added an epilogue entitled “Aspective” in which she reconsidered the proto-perspectival methods of pre-Greek art. Meanwhile, Groenewegen-Frankfort (1951), was conscious that pre-Greek art did not have perspective in the modern sense and explicitly pointed out that it was misleading even to use terms such as cavalier perspective (119, 135) in this context. Her concern was however to understand the background that led to objects being represented as they appear to be seen, which involves a relation to an observer and as she noted had two basic implications (3):

Firstly, all rendering which aims at illusionary corporeality- and we shall in future refer to it as functional rendering- implies on the one hand, a wilful act in the choice of viewpoint and, on the other, a resignation in that it accepts the autocracy of the solid form, its inner coherence: no mere viewpoint can tamper with the co-ordination of its parts; foreshortening, overlapping must be registered. And secondly, an object thus rendered is conceived as existing in space, the familiar three-dimensional space which comprises both it and its observer; in fact, corporeality and space are concepts which mutually require each other. Consequently the surface on which the image appears is no longer self sufficient. As substitute for the transparent screen it loses as it were, its solidity, becomes the isolated image of a figure rendered as observed, by a conceptual, three-dimensional void, appears to exist in space.

Groenewegen-Frankfort relates these problems of space to those of time and narrative in an attempt to explain both the Arrest and movement in the title of her book. Although focussed on art of the ancient near east, this work, like that of Schäfer raises fundamental questions concerning the nature of representation and provides an important context for understanding later periods.

Antiquity (1000 B.C.-321 A.D.).

During the Renaissance, the first authors on perspective denied that it had existed in Antiquity. Alberti (1434) remarked: “Since this work seems impossible of execution in our times, if I judge rightly, it was probably unknown and unthought of among the Ancients.” Filarete was more assertive: “It was not used by the ancients, for even though their intellects were very subtle and sharp, they still never used or understood perspective.”

The first important source for the assumption that perspective originated in Antiquity was a passage in Vitruvius’ Ten books of architecture which referred to scenography and
claimed that at the time of Aeschylus, Agatharcus had painted a scene and had written a treatise on the subject as had Democritus and Anaxagoras:

showing how, given a centre in a definite place, the lines should naturally correspond with due regard to the point of sight and the divergence of the visual rays, so that by this deception a faithful representation of the appearance of buildings might be given in painted scenery, and so that, though all is drawn on a vertical flat facade, some parts may seem to be withdrawing into the background, and others to be standing out in front.284

Cesariano, in his famous edition of Vitruvius (Como, 1521), Caporali (1536), Ryff (1547), and subsequent commentators accepted this passage at face value and assumed that scenography was synonymous with perspective. Philologists such as Ermolao Barbaro raised doubts whether Vitruvius intended sciographia rather than scenographia, but this did not reverse the basic interpretation, and even today the passage remains an important ingredient in debates.

Philostratus, in his Images, referred to deceiving the eyes in terms of symmetria. The early Renaissance editions translated this Greek term as proportion (proportio), but in 1578 a French edition translated this term as perspective. Further evidence based on texts was collected by Ioannes Schefferus in his book on Graphics, that is, on the art of painting (1669), in which he described proportion as a third part of painting and related this to Cicero’s convenience of parts (convenientia partium); symmetry in Pliny the Elder; congruence in Pliny, competence in Aulus Gellius; the terms commensus and commodulatio in Vitruvius and the Greek term for harmonics. Citing Pliny, Schefferus claimed that the first to practice this method in Antiquity was Euphranor, who taught the rules to Parrhasius. Among modern practitioners Schefferus mentioned authors of perspective texts such as Dürer, Gauricus, Serlio, Ryff, and Lautensack.

Doubts concerning ancient perspective grew in the seventeenth century. Rubens in a letter to Pieresc written on the sixteenth of March, 1636 commented on a Nymphaeum found in the gardens of Cardinal Barberini in Rome:

This appears to be the work of a good painter but the optics has not been carefully observed, for the lines of the buildings do not intersect the horizon at an equal height, and to put it in a word, the whole perspective is lacking. One finds similar errors in certain buildings represented on the backs of medals...This leads me to conjecture that in spite of the excellent optical precepts given by Euclid and others, this science (perspective) was not nearly as commonly known by all as it is today.285

The grounds for a serious debate on the question whether or not the Ancients had known perspective were prepared when the French architect, Claude Perrault, offered evidence that the Greeks had been ignorant of perspective in his Parallel of the ancients and moderns (1692). Perrault cited the example of the Column of Trajan, noting how the figures further back were not diminished in size. He also claimed that Zeuxis and Apelles never knew the part of painting which involved the composition of a panel following the rules of diminution. Perrault’s arguments provoked the Abbé Sallier (1728) to claim that the Ancients must have had some knowledge of perspective. While careful to
acknowledge that their level of theory may have been less extensive than during the Renaissance, Sallier based his claims on three sources, beginning with Plato’s discussion of appearance (*phantastike*) in the *Sophist*. Plato had noted that whereas sculptors maintained the true proportions of objects, painters did not, and had described the principle of optical adjustments methods (235e-236a):

> objects which are seen at a certain elevation will appear too small and those which are positioned lower will appear too large, the ones being viewed from nearby, the others from afar. That is why workers these days abandon the true and give to their figures not the real measure of the model but that which should produce to the eye the impression of beauty of those figures.

In Sallier’s interpretation this description of optical adjustments was evidence of perspective. Next he considered the passage from Vitruvius cited above, before turning to passages in Pliny’s *Natural history*. That the painter Pamphilus was described as being very learned in all the arts and especially in geometry convinced Sallier that he must have had some idea of perspective. Pliny had also described how Apelles ceded to Amphion in disposition, to Asclepiodorus in measures, the degree to which one thing should stand distant from another. This again Sallier interpreted to mean perspective. Franciscus Junius (1638) shared similar views claiming that the paintings of Apelles and Protogenes were proper courses in painting in which one could not doubt that perspective was dealt with thoroughly.

Sallier’s article stimulated the learned antiquarian, M. le comte de Caylus, to pursue the theme *Of perspective of the Ancients* (1741) defining perspective as “the change and diminution that air brings to the colour and distance brings to line in objects seen by the eye”286. Caylus mentioned second-hand reports of recently excavated paintings from Herculaneum, but remained suspicious of what for him was hearsay. He cited Euclid’s *Optics* as evidence that the Greeks had a sufficient optical knowledge to achieve perspective. He referred to Junius (1638) and examples of Roman painting, the *Aldobrandine Marriage*, which Rubens had criticized for lack of perspective in his letter of 1636 cited above (cf. Sulzberger 1941, 1956); sculptures, such as the *Feast of Trimalcion*; marble bas-reliefs; medals and engraved stones.

Meanwhile, in England, interest in this debate had also been growing. Alexander Pope, in his edition of the *Iliad* (1721), claimed that perspective had already been fully known at the time of Homer. Turnbull (1753), more cautious, was nonetheless persuaded by Sallier’s claims (70): “that whatever reason there may be to doubt whether perspective was well understood by the Ancients or whether the ancient painters had rules of perspective.... there is none at all to doubt, but they were able at least by the judgement of the eye, to represent and counterfeit any visible appearances”. Turnbull supported these claims by citing passages from Plato, Vitruvius and Philostratus. His contemporary, Webb (1760), cited the same passages without acknowledgment to reach a more dramatic conclusion (115-116): “By this it will appear that the Greek painters, not only knew the rules and studied the effects of perspective, but that their greatest philosophers and mathematicians, thought it worthy of their attention, to reduce these effects to sure and determined laws”.

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These debates were also taken up in Germany. Lippert (1767-1776), denied that the Greeks had known perspective. Klopstock (1767) rejected both the extreme views of Perrault and Pope and agreed instead with Sallier that there had been some knowledge of its principles among the Greeks and Romans. In addition to the usual passages from Plato, Philostratus, Pliny and Vitruvius, he cited additional evidence of paintings from Herculaneum and ancient coins. Klotz (1768) was even more certain that the Ancients had known perspective and cited as new evidence a cut stone in his collection and a passage from Lucian. Lessing had denied that the Greeks knew perspective in his *Laokoon* (1766) and took up the matter anew in his *Ninth Letter of Antiquarian Contents* (1768) as a reply to Klotz. According to Lessing, Klotz had used the term perspective too loosely to refer to diminution of figures in general. Similarly Klotz had used the term military perspective vaguely and had pretended that perspective was a question of genius when it was in fact a matter of mastering basic technical rules which, once established, could be carried out by anyone. Casanova (1770), took a similar tack and claimed that the passage of Philostratus upon which Webb had focussed merely proved that there was a general sense of foreshortening, which was a long way from laws of perspective.

If we look back over these debates in the forty year period from 1728 to 1768, some significant changes become evident. At the outset Sallier was simply citing ancient texts uncritically. Le comte de Caylus shifted discussion from textual evidence to include works of art. Both were writing in French commenting on the views of other Frenchmen. In the next decades this debate became international and involved English and German as well as French scholars. Moreover, Lessing and his German contemporaries, introduced an element of interpretation. It was not just a question of citing texts, but rather of analysing critically their meaning. There was also a challenge of reconciling opposing interpretations. Fiorillo (1803) is an excellent summary of these new methods. He noted that perspective had a whole range of connotations to different commentators including scenography, composition, the shape of every foreshortened object, diminution of figures, gradual disappearance of chiaroscuro and diminution of colours etc. He cited the passages in question from Vitruvius, Philostratus, new passages from Pliny and reported the opinions of various scholars from Perrault onwards, carefully weighing the pros and cons of Lessing’s debate with Pope and Klotz. His conclusions were less original: that the ancient artists had known and practiced perspective but had sometimes made errors in execution. But then, he added, so too had Guido Reni and no one would accuse a student of Carracci of ignorance of perspective.

Nineteenth century contributions to these debates were less dramatic than those of the eighteenth century. Nonetheless, some clear developments deserve mention. In mathematics, Poncelet (1821, xxxvii) drew attention to the importance of the porisms of Euclid. This was one of the starting points for Chales (1837) in his *History of geometry* who raised the question whether the Ancients knew perspective and concluded that (74): “in spite of all the respect that we have for this great geometer [i.e. Poncelet], we must confess that in reading the Ancients we have not found any trace, any indication which would authorize us to share his opinion in this matter”. Indeed, Chales (cf. below p. 69*), believed that Desargues and Pascal had been the first to apply perspective to the theory of conics.
In archaeology, ever more detailed measurement of ancient architecture led to a new awareness of optical adjustments made by the ancients. Hoffer (1838) made a preliminary report on new measurements of the Parthenon. Pennethorne (1844) offered a larger framework for understanding these adjustments. His ideas were taken up by Penrose (1846) and in an unpublished work of Paccard in the same period. Not everyone was convinced that these curvatures in the Parthenon had been intentional. The possibility that they might have come about through a sagging of the foundations was considered by Bötticher (1862) and Ziller (1865). Further studies of Durm (1871) and Burnouf (1875) gradually established that these curvatures had indeed been intentional. Hauck (1879), in an important study related these curvatures to Greek optical theories and in so doing prepared the way for Goodyear’s (1912) studies and Panofsky’s (1927) claims.

Nineteenth century developments in philology also brought new precision. For instance, Mullach’s (1843) list of works by Democritus gave a Greek title *Ekretasmata* for his work on scenography and provided learned notes. A French edition of Philostratus (1881) considered the supposed reference to perspective in a commentary. An article by Sartorius (1897) assessed the question of perspective in the context of Plato’s views on painting with detailed references to the original Greek. Meanwhile a number of scholars continued the general textual approach of the previous century. Some, such as Thibaut (1827), merely summarized what had already been said. Others such as Randoni (1825) offered a more sceptical assessment of the ancient contribution. While accepting that there had obviously been optical adjustments methods, he insisted that a distinction was needed between the general drawings of stage scenery which were known to the Ancients and drawings using linear perspective which were not. Randoni based this claim on a close reading of the passage from Vitruvius, arguing that the Latin term *circini centrum* had nothing to do with the centre of the eye and referred simply to an opening of the compass. Wieland (1840), also of interest for perspective in literature (see below p.119*), found a passage in Cicero’s *Orator* which he thought offered further proof of perspective in Antiquity.

Already in the eighteenth century scholars had recognized Pausanias as one of the richest classical sources for descriptions of Greek art. His detailed description of the murals painted by Polygnotus in the hall of the Knidians at Delphi was particularly problematic because no physical evidence remained of these once great murals. The Comte de Caylus had outlined an imaginative reconstruction of this narrative cycle as being complete with illusionism, spatial effects and perspective. Klotz had taken up this interpretation only to be challenged by Lessing. Schreiber (1897) reviewed the history of these debates and introduced a new approach by noting that the concept of symmetry applied to the disposition of groups of individuals as well as to individual figures. This he demonstrated using well known examples such as the *Aldobrandine Wedding* in the Vatican and images on a series of amphora. Schreiber concluded that ancient art, to the extent that it involved distinct episodes of narrative and architectural features, was dominated by a principle of concentric arrangements of one to three figures around a central individual in the foreground. These symmetrical arrangements were sometimes shifted slightly to produce variation in the eurythmic effects. Schreiber pointed out that these principles continued into the Renaissance in Masaccio’s frescoes in the Brancacci Chapel and those of Ghirlandaio in Santa Trinità.
Meanwhile, Blondel (1878), who marked one of the most subtle nineteenth century contributions to the tradition of interpreting ancient sources, heralded a new approach by adding some careful line drawings and photographs of the works in question. From the time of Caylus (1741) scholars had mentioned and cited visual evidence from Herculaneum and other sites. Thibaut (1827) had referred to Pompeii. But this had been prior to the invention of photography and even when photographs became possible, the limitations of printing meant that good reproductions were still not practical in learned books and journals. This changed dramatically in the early twentieth century just as new archaeological digs were uncovering the Villa Boscoreale in Pompeii. For instance, Petersen (1903), included three photographs of this villa in an attack on Mau, to which Mau (1903) responded in the same issue with seven photographs, some of fragments of paintings which he completed and reconstructed using line drawings.

This new use of photographic documentation went hand in hand with a shift in the debates to consider functions of the original paintings. Mau claimed that they were more by way of ornamental decorations, hence the tendency of these frescoes to occlude space beyond the room. This idea was pursued by Krieger (1919) using new evidence from the Villa Negroni, Hadrian’s Villa and the walls of the tomb of the Nasoni. On the other hand, Petersen argued that the Pompeian frescoes were prospects and thus effectively like windows into the landscapes. Kern (1912, cf. below p. 50*) and Goldschmidt (1916) subsequently argued that this ancient tradition was the source of mediaeval and fourteenth century examples.

Rodenwaldt’s (1909) publication of the composition of the Pompeian wall paintings, prompted Pfuhl (1910) to reconsider references to Apollodorus as a shadow painter (ο σκιαγραφος) as possible allusions to his work on perspective. Pfuhl (1911) also drew attention to the importance of vases as another indirect source for the lost paintings of the Greeks, including eleven illustrations. This led to his classic Painting and Drawing of the Greeks (1923). Pfuhl’s work was one of the starting points for a dissertation in Latin by Hoogeveen (1925) on questions of depth and perspective in ancient art, which included no illustrations because these were supposedly sufficiently wide-spread. Kaphingst (1924) avoided illustrations in his thesis for another reason. The paintings were lost and the evidence of vases was too meagre. Consequently he focused instead on philosophical, astronomical and scientific fragments by Plato, Aristotle, and Theophrastus, citing scattered references in Greek (without translation), to the work of Anaxagoras and Democritus in order to understand the background for ancient writings in optics and perspective, notably Euclid. Meanwhile, Panofsky was formulating his theory of ancient fish-bone perspective (see above p. 4) in lectures at the Warburg Library (1924-1925) which he published in 1927. Curtius (1929) devoted some ten pages (86,117,157,176,184,310, 314,341,392,394) to perspective in his study of the wall paintings of Pompeii (pl. 1.1-2; 33-34).

Little (1937) basically accepted Panofsky’s explanation but claimed that they had also had a knowledge of two-point perspective. Kern (1938) analysed the mosaic of the Four Seasons (Munich, Glyptothek) to demonstrate that it had (a fish-bone) perspective and used the scenae frons from the Domus Aurea to reconsider the passage in Vitruvius. Beyen (1938), in his massive publication on the Pompeian decorations, provided much new visual evidence and noted a contradiction between references to systematic
perspective in ancient texts and lack of perspective in the extant wall paintings. The following year Beyen (1939) published two articles claiming that the visual evidence of the wall paintings in fact confirmed knowledge of a systematic method of central perspective. The 1940’s saw at least four contributions. Bunim (1940) reassessed various interpretations of the passages from Vitruvius. Levy (1943) wrote a general article in which he claimed Greek perspective had influenced both Renaissance and modern art. Richter (1946) provided important material on Attic red-figured vases. Lepik (1949) examined the mathematical planning of ancient theatres. Eith (1947) returned to the question of curvatures in Greek temples examining images in the eye from a medical, ophthalmological point of view.

Since 1950 there have been a number of contributions. New attention was given to the importance of vase painting. Robertson (1951) offered a brief survey of its development. Beyen (1952) considered a Loutrophoros to reassess the famous passage in Vitruvius. Schweizer (1953) drew on examples of vase painting in a study which explored the roots of perspective in Plato’s philosophy and aesthetics. White (1956) confronted evidence from written sources with visual evidence from Pompeian wall paintings and vases, drawing attention in particular to foreshortened chairs depicted therein. He re-examined carefully the Vitruvian passages and concluded that the ancients must have known linear perspective. The following year he published an abbreviated version of this as a chapter in his Birth and Rebirth of Pictorial Space (1957). That same year MacNair (1957) reviewed the tradition of optical adjustments methods in architecture under the title of spherical perspective. Andreae (1958) examined the spatial characteristics of the Amphora of the Giants from Melos at the Louvre and noted that these were more effective on the original vase than in copies which had been unrolled onto a flat surface.

Also that same year Gioseffi (1957) produced both a significant article which became the basis for an important book both of which took John White’s Birth and rebirth as a point of departure. In the initial section of his article Gioseffi focussed on the Massacre of the Niobes (Strage dei Niobidi, Museo Nazionale, Naples) as evidence of linear perspective in Antiquity and claimed that Apollodorus of Athens, the so called shadow-painter (skiagraphos), was the first of the Greeks who reproduced visible appearances. In the early section (1-47) of his book on Artificial perspective, Gioseffi (1957) re-considered the classical sources that discussed perspective, namely, Vitruvius, Ptolemy, Daminaus and Proclus. Gioseffi reviewed and dismissed the theories of Borissavlievich and Panofsky, noting that a concept of potential infinity had been admitted by Aristotle. According to Gioseffi there were clear examples of mathematical perspective to be found at Pompeii. He cited as evidence cubicle 16 in the Villa of the Mysteries (pl. 2.1-2.2), cited the use of diagonals in cubicle 14 and the converging lines in both oecus 6 and right side of the wall in alcove b of cubicle 8 in the same villa.

Since then the most important evidence in favour of Ancient methods approximating those of linear perspective have been provided by the excavations at Oplontis (1975). Here we find receding rows of columns (pl. 3.1-2), which appear at first glance to recede towards a single vanishing point.
Figs. 7-8. Line drawings of Cryptoporticus, Pompeii, with reconstructions according to Little, (1971). The same with extensions by the author of some of the other converging lines to confirm that this is an other example of axial (fishbone) perspective.

We discover, however, that different parts of the picture converge to different points along the axis: i.e. that this is another case of fish-bone or axial (pseudo-) perspective, and that this motif is a recurrent one even in the context of this single villa (pl. 4.1-2). Even so this effect is reminiscent of Lucretius’ description in *The Nature of Things* (see Appendix 1).

Much important evidence against the existence of linear perspective in Antiquity was provided by the work on vases by Beazley (1956, 1963) and Richter (1946, 1966). The role of vase painting in the development of realism in Greek painting was examined in detail by Moreno (1964-1965). Additional examples of architectural representations on Greek vases were provided in dissertations by Gigante (1980) and Adamopoulos (1986). Further evidence from the walls of Pompeii and Herculaneum was made accessible by Schefold (1962), by Kraus and Von Matt (1973) and through an excellent exhibition catalogue sponsored by the Ecole des beaux arts (Paris), the Institut Français (Naples) and the Getty Trust.

A series of articles dealt with specialized topics. For instance, new attention was given to the problem of optical adjustments. Stucchi (1952-1954) examined the decorations of the temple of Zeus at Olympia and wrote on optical corrections in Greek art (1955). Stucchi (1970) also proposed that the Charioteer at Delphi was intended to be seen from a given point of view. Purchiaroni (1959-1960) considered the problem of optical corrections in the Hephaesteion of Athene. Stewart (1977) proposed that the sculptures from the cave at Sperlonga were programmatically arranged to be seen from a special position: the emperor’s dinner table. Bertocchi (1961) drew attention to landscape scenes in the Ambrosian *Iliad*. Andreae (1962) re-examined the spatial effects of the *Odyssey*.
Landscapes (Vatican). Adorno (1965) considered perspectival problems in his reassessment of Plato and Aristotle’s views on art. An important article by Wataghin Cantino (1969) studied the development of bird’s eye views in ancient painting. Keuls (1975) reconsidered the meaning of *skiaographia* to conclude that it “was an impressionistic technique, using divisions of bright colours and relying on the phenomenon of optical colour fusion”, only to be challenged by Pemberton (1976). A conference at the Swiss Institute in Rome included essays by Lasserre (1985) on Agatharchus, Gioseffi (1985) on Democritus and Krause (1985) who related the problem of Ancient scenography to the architectural tradition which intended that temples be seen from given viewpoints.

Most of these specialized studies have had little impact on two camps which have been emerging. One insists that the Greeks had a technical knowledge of perspective. White (1957 etc.) and Little (1971) have become the best known exponents of this view. Little’s diagrams are persuasive (e.g. fig. 7) until one recognizes that he has “omitted” extensions to some of the converging lines. If these are added, one obtains another example of the by now familiar axial perspective (fig. 8).

The other camp claims that the Greeks had no technical knowledge of perspective. For instance, Lepik-Kopaczynska (1956), argued that the pervasive evidence of false perspective in Greek art could not be a coincidence and suggested that one should distinguish between three kinds of pseudo-perspectival techniques, relating to frontal, lateral and oblique views respectively. Richter (1937) also suggested that the Greeks had no technical knowledge of perspective, a view reinforced by her detailed studies of vases (1946, 1966) and which led her to make (1970) what remains the best statement against ancient perspective.

Among historians of mathematics and science there was some discussion of the role of Euclid’s *Optics* in the rise of perspective. Veltman (1975, 1980, 1986) accepted Panofsky’s conclusions and offered further reasons for maintaining this position. Brownson (1981) challenged Panofsky’s (1927) claim that Euclid’s theory of vision precluded principles of linear perspective, arguing that five propositions (10, 18-21) employed linear projection albeit he admitted that only one of these (10) involved a visual cone. Andersen (1987) acknowledged proposition 10 as the “one procedure resembling a projection”, but concluded that Euclid did not use proposition ten for these purposes. Knorr (1991) went further, arguing that the crucial passage in proposition 10 was not part of the original text and represented a later gloss. He thus rejected links between Euclid’s *Optics* and linear perspective.

One reason why there remains so much debate concerning these questions is because classicists and especially classical archaeologists frequently use perspective in a broad sense to include all effects of foreshortening and diminution with distance. This the Greeks and Romans undoubtedly had. They also undoubtedly had some techniques of optical adjustments and corrections. The combined literary evidence suggests that they had some systematic method to produce pseudo-perspectival effects. There is no convincing evidence however that they knew linear perspective as developed in the Renaissance. Indeed, as Panofsky (1927 etc. cf. Veltman 1975, 1986, 1992) claimed, there are serious reasons to insist that the ancients could not develop perspective in the
modern sense. If Euclid’s *Elements* potentially made perspective possible, Euclid’s *Optics*, which appears to have guided methods of representation, precluded the inverse size/distance principles on which perspective is based. Hence, while many have spoken eloquently about the re-discovery or re-invention of perspective in the Renaissance, the weight of the evidence to date suggests that linear perspective, in a technical sense, was discovered for the first time in the early decades of the fifteenth century.

**Mediaeval Period (321-1300)**

The mediaeval period as a whole has received remarkably little attention. Those who claim that perspective was discovered in Antiquity usually assume that it was forgotten with the fall of Rome and not recovered until the Renaissance. On the other hand, those who believe that perspective was discovered by Brunelleschi in the Renaissance frequently search for proto-perspectival examples in Cavallini (Santa Maria in Trastevere), Lorenzetti (Siena, Assisi) or Giotto’s cycles (Assisi, Padua, Florence) and in so doing they treat these late thirteenth and fourteenth century examples as if they were part of the early Renaissance. Both schools focus on beginnings rather than continuities, and hence the period in between is usually ignored.

One of the rare exceptions was Kallab (1900), who argued that the importance of symbolic elements such as tower, arch, crenellated wall and throne during the mediaeval period required the development of some spatial mastery. Another was Panofsky (1927) who made several important points in his landmark article. He noted the existence of inverted perspective in mosaics of the sixth century, and a serious interest in spatial motifs in the Vienna *Genesis* (c.500 A.D.). He demonstrated that a type of round temple represented in a villa near Boscoreale (now New York, Metropolitan Museum), recurred in Syrian (c. 500 A.D.), and Latin manuscripts (c. 781-783; c.827; c.870). Panofsky showed that the axial (or fishbone) perspective of Roman art, recurred in the *Alcuin Bible* (London) in the second quarter of the ninth century, and in Duccio’s *Maestà* (c.1301-1308).

He observed that subjects such as the *Last Supper* were being treated in spatial terms by the twelfth century at Monreale and that a mosaic depicting *Christ healing the Lame* in that great monastery had a set of tiles converging to a single point. Panofsky established also that while Italian artists such as Lorenzetti played an important role in the evolution of these converging tiles in the fourteenth century (pl. 7.3-4), one needed to take into account northern examples such as Meister Bertram (1379) or the anonymous Missal of Luçon (c.1388). Similarly the spatial interiors of Jan Van Eyck had parallels in the Master of Heilgenthal (Konrad von Vechta?). Implicit in Panofsky’s study was the claim that the development of spatial motifs in the Renaissance was a European rather an Italian phenomenon, although it was in Italy that mathematical perspective emerged. Pinder (1934) suggested that the rise of perspective had undermined the higher ideals of form in mediaeval art, and basic values of belief and community that were above form.

Panofsky’s essay was one of the starting points for Horb (1938), who examined in more detail the continuity between Pompeian frescoes, early Christian churches such as San Lorenzo fuori le mure and the work of Duccio and Giotto in the Trecento. He argued specifically that the view of an interior as a section which simultaneously gave one a view of the exterior had its roots in Pompeian art, that it could be traced via a fourth
century Vergil manuscript (Rome, Vatican 3225) and later examples such as the Vienna \textit{Genesis} manuscripts. Panofsky also inspired Bunim (1940), which remains the most systematic study of mediaeval space thus far. Bunim identified two basic spatial forms in Roman art. One was a “stage space” which included prospect scenes. While maintaining a vestige of its original stage space structure, this involved a solidifying of the surface to achieve concrete tridimensional forms. A second tradition “derived from the impressionist form of the backgrounds found in the \textit{Odyssey Landscapes}” and by “substantializing the surface of an illusionistic, representative picture plane”, arrived at stage space by a series of modifications. Bunim contrasted developments in Byzantine and Italian art, which were dominated by the tradition of stage space, with developments in Germany, France, and England which were dominated by illusionistic space until the thirteenth century when Germany, and the fourteenth century when France and England introduced a stage space. Bunim’s book was reprinted (1970). No subsequent study has explored questions of continuity and development of space during the entire mediaeval period in greater detail.

For the period from 1250-1500, White (1957), remains the standard work. Following the example of Vasari he began his account of the rebirth of pictorial space in the Upper Church of San Francesco at Assisi with Cimabue; the master of the \textit{Legend of Saint Francis}, the Saint Cecilia Master and the painter of bays seven and eight. To explain the context of these developments in Assisi, White turned to Rome, noting the role of Cavallini and that (51-52): “the entire decorative framework of the Saint Francis cycle derives from Roman prototypes, San Paolo amongst them, whilst Cimabue’s frescoes of the Lives of Saints Peter and Paul depend, in all probability, on the lost series in the portico of Old Saint Peter’s....It was in Rome that Italian painters first rediscovered nature through the art of late antiquity”.

White then turned to Giotto’s role in the Arena chapel in Padua and in the Bardi and Peruzzi Chapels of Santa Croce in Florence, before considering the contributions of two early Sienese masters: Duccio di Buoninsegna and Simone Martini. He suggested that Giotto’s \textit{Wedding Feast at Cana} in the Arena Chapel marked a starting point for the later evolution of Giottesque perspective and that its treatment of oblique perspective could be traced via the master of the Saint Nicholas Chapel in the Lower Church of San Francesco at Assisi and Maso di Banco’s frescoes in the Bardi di Vernio chapel of Santa Croce. White observed that Taddeo Gaddi’s use of an extreme oblique design in his \textit{Presentation of the Virgin} in Santa Croce recurred in the \textit{Très Riches heures du Duc De Berry} by Pol de Limbourg; he noted how the conquest of the barriers between reality and art was achieved by a play of painted architectural frames in Assisi, Padua and at Santa Croce in Florence.

White focussed on three artists active in Padua in the last quarter of the fourteenth century (Altichiero, Avanzo and Giusto de’Menabuoi) in terms of their compositional content, and developments in spatial design. Following a chapter on Brunelleschi’s perspective demonstrations, White traced the contributions of Masolino, Donatello, Ghiberti and Filippo Lippi. He explored briefly the problem of illusionism in painting and outlined the development of what he termed synthetic perspective in Uccello and Leonardo da Vinci. He explored parallels in French manuscript illustration via Jean de Pucelle, the Limbourg brothers and particularly Jean Fouquet. A final chapter was
devoted to re-assessing the question of the discovery of perspective in Antiquity (cf. above p.44*).

Gioseffi (1957), in the second section (48-73) of his book on Artificial perspective, challenged the explanations of Grabar (1945) and Stefanini (1956) concerning inverted perspective (see below p. 95-96*) and argued that there existed no coherent method of inverted perspective, only episodes that go inversely and that the phenomenon was rather to be understood as a fragmentation of perspectival space. By way of illustration, Gioseffi cited the Sacrifice of Abel and Melchisedech (Ravenna, San Vitale, pl. 15) which he claimed showed two separate perspectival spaces. Gioseffi also reconsidered Giotto’s contribution, making three claims, first, that Giotto had known the basic principles of linear perspective: citing the fictive alcoves (Padua, Arena Chapel) as an example. Second, he claimed that Giotto’s work at Padua and Assisi contained the first applications of a single vanishing point for a whole space: Giotto’s Sermon in the presence of the pope (Predica davanti al papa) was cited as an example. Third, he claimed that some works included a vanishing point and diagonals: for this he cited the Prayer for the miracle of the rods (La Preghiera dei pretendenti, pl. 7.1-7.2). According to Gioseffi these examples confirmed that Giotto had depended on examples of ancient art which would have come into his ken through Roman intermediaries such as the Isaac Master (Maestro di Isacco) and the Master of Saint Cecilia.

That same year, Parronchi (1957), in a highly imaginative and no less speculative article on “The Sources of Paolo Uccello”, raised new questions in terms of the late mediaeval contribution. He suggested, for instance, two strands of development from the time of Giotto. The optical writer Witelo had claimed that parallel lines do not converge with distance. One strand, which included Maso, Stefano, Giottno, Brunelleschi and Masaccio, deliberately went against this prevailing optical theory and insisted on making parallel lines converge to a point. Meanwhile, claimed Parronchi, there had been another strand, more peripheral, which included Taddeo Gaddi, Orcagna and Uccello, and followed more closely the precepts of Witelo’s optics. Parronchi found that Uccello’s compositions lent themselves to be circumscribed by geometrical circles. He believed that there were parallels in Witelo’s optics. More significantly, he thought, Uccello’s sinopia in Santa Maria alla Scala evidenced two diverging vanishing points which, he believed, corresponded to a diagram in Witelo’s optics (Bk. III, 45) dealing with binocular vision. In the second part of his article Parronchi suggested parallels linking Uccello’s work with the anonymous On Perspective which he ascribed to Toscanelli; with Aristotelian ideas supposedly acquired second hand through the summa literature; with the Secret of Secrets, and with a treatise On the Moral Eye. From all this Uccello emerged as “a painter with a basis in philosophy who through the lens of optics tried to reflect the Aristotelian cosmos in his paintings”.

The following year Parronchi continued his exploration of mediaeval optics and its role in the “Two Perspectival Panels of Brunelleschi” (1958), examining the influence of Alhazen, Witelo, Bacon, Peckham, Blasius of Parma, the anonymous author of On Perspective and Ghiberti’s Third Commentary. In Witelo’s Optics he found a diagram (V.23) which, he believed, could have inspired Brunelleschi to make his original experiment. He cited once again the concept of binocular vision to which he returned in “The Measures of the Eye According to Ghiberti” (1961), where he argued that the
spatial arrangement of the vanishing points in Ghiberti’s scenes from the *Stories of Jacob and Joseph* on the doors of the Baptistry at Florence (the Gates of Paradise), was in accordance with binocular principles of mediaeval optics. Parronchi argued that the eye which guided fourteenth century architects was based on a concept of deception of the eye as found in optical treatises of the time and that this could account for their lack of clear quantitative measurement. In his view Brunelleschi transformed this approach first in Santa Trinità and then in Santa Maria del Fiore.

Meanwhile, Parronchi had written another important article on perspective at the time of Dante (1960). Here he examined the impact of mediaeval optics on Dante’s ideas, confronting paragraphs from Roger Bacon and Thomas Aquinas with passages from Dante’s *Convivio* and exploring parallels between ideas in Alhazen and Witelo with those in Dante. Parronchi (1960-1961), in his “Visualized architecture” suggested that treatises on optics (*perspectiva*) had been a source of geometrical knowledge to mediaeval architects. To demonstrate these links between architecture and optics Parronchi cited examples of portals in Florence (S. Stefano in Ponte) and Prato (Duomo) the framing bricks of which converged towards a central vanishing point and examined the play of light through windows into churches such as Santa Trinità in Florence. These and other articles were reprinted in Parronchi’s book (1964) which, though challenged in many points of detail by Edgerton and others, remains one of the classics in the field.

The following year saw the appearance of another classic, Federici Vescovini’s (1965), *Studies on mediaeval perspective*, which has not received the attention that it deserves. Vecovini focussed on the philosophical context of mediaeval optics in the period 1200-1400, beginning with Grosseteste’s quest to make optics (*perspectiva*) a demonstrative science. She then examined three texts in the neo-Platonic tradition, the *Book of causes* by Pseudo-Avicenna, *On light* by Bartolommeo da Bologna and *On intelligences* by Pseudo-Witelo. She traced the influence of the Stoic tradition via Alkindi, explored roger Bacon’s efforts to make optics an experimental science, the role of Avicenna, Arabic medical sources, and the gnoseological-optical approach of Ibn al Haytham. The latter part of the book focussed on the contributions of the major fourteenth century authors on optics: Buridan, Henry of Langenstein, Domenicus of Chivasso, a commentator on Euclid, and Blasius of Parma. Vescovini’s importance lies in showing clearly that mediaeval optics was much more than theories about the eye. Indeed optics was central to the major philosophical discussions of the time. She concluded that with the work of Blasius of Parma, the neo-Platonic theoretical approach to vision (267): “is transformed...into a privileging of an empirical, experimental and quantitative understandstand of nature, on the basis of a different use of geometrical notions of optics from Antiquity”\(^{288}\).
Fig. 9. Map of major developments in perspective in the period 1200-1700 by Harnest (1971).
Since then other contributions have been made. Ineichen (1975) explored the etymological links of optics and perspective in the Arabic term *al-manazir*, particularly as used by Alhazen. Veltman (1986) drew attention to Villard de Honnecourt’s (c.1230) use of a strings and nails to make voussoirs which bears an unexpected similarity to the so called workshop method of arriving at vanishing points described by Klein (pl. 5.1). Sabra (1992), published the first two volumes of his monumental edition of Alhazen’s *Book on vision* (see above p. 26*), making available for the first time to English readers the riches of the Arabic optical tradition, thus clarifying the context whereby the study of vision became intertwined with concerns for representation.

**Renaissance (1300-1599)**

The history of Renaissance perspective involves both practice and theory. Most literature on these subjects has been devoted to individual practitioners and theorists and, for the sake of convenience, has been listed separately in alphabetical order in Appendices 3 and 4. Our concern in this section will be focussed on accounts which deal with the period as a whole.

Among the earliest records of Renaissance perspectival practice was Cristoforo Landino’s *Apologia of Dante* (1481, 1564; cf. Morisani, 1953), who specifically used the term perspective in his descriptions of Uccello, Brunelleschi and Donatello. In his *Apologia of the Florentines* (cf. Bonucci, 1847,91) Landino also described Leon Battista Alberti as being “more famous in perspective than anyone in many centuries”. Massaino (1499) noted Alberti’s accomplishments in perspective theory (cf. Bonucci, 1843, p.CCXXXV). Volaterannus (1506) in his discussion of optics and catoptrics referred to the treatises of Petrus e Burgo Sancti Sepulchri (i.e. Piero della Francesca) adding that: “the use of this discipline is clearly manifest in many things: in measuring buildings, in the principles of architecture and painting, in the positioning of the shadows of objects...and finally in discovering the truth and variety of heavenly and other bodies both in terms of their reflections and refractions”. Volaterannus’ statement is important because it makes explicit links between perspective, optics and astronomy which helps explain Leonardo’s and Kepler’s activities in this context (cf. Veltman 1994). It also provides a further context for Edgerton’s (1991) claims concerning links between astronomy and perspective.

Vasari (1550) began his story of perspectival practice with Cimabue, Giotto and Stefano; mentioned Paolo Uccello, Filippo Brunelleschi, Lorenzo Ghiberti, Masolino and Masaccio among the early masters of perspective and specifically referred to Andrea Verrocchio and Piero della Francesca as perspectivists. Indeed his description of perspectival practice was so detailed that it was not until the twentieth century that scholars compared the details of that story with extant painting in arriving at a more accurate history. In terms of theory Vasari mentioned Brunelleschi’s demonstration and also referred to treatises on perspective, although not to specific titles. A survey of Vasari’s statements on perspective is provided in appendix 5.

The same trends in nineteenth century scholarship which led to a new study of source materials and prompted new attention to the sources of perspective (cf. above p. 3*) led also to new studies of Renaissance perspective. The long articles and monographs by Nielsen (1895-1901) heralded a more systematic approach. In the earliest of these,
Nielsen (1895), focussed on the work of Albrecht Dürer. Nielsen (1896), began with the proto-perspectival efforts of Cimabue and Giotto and explored the foundations of perspective theory in Brunelleschi and his contemporaries Uccello, Ghiberti, and Masaccio and went on to outline the contributions of Alberti, Piero and Pacioli. The latter part of the book examined painting practice in the Netherlandish school; Mantegna, and perspectival practice in Florence (Filippo Lippi, Benozzo Gozzoli, Melozzo da Forli, Luca Signorelli, Domenico Ghirlandaio and Botticelli). Nielsen (1897) turned to the work of Leonardo da Vinci, the contributions of the Umbrian school (Bramante, Perugino, Pinturicchio and Santi), Raphael, Peruzzi, Giulio Romano and Michelangelo.

Nielsen (1898), began with a chapter on the Venetian school including the Bellini family, Carpaccio, Giorgione, Titian and Veronese (cf. pl. 35). This was followed by chapters on Serlio and Barbaro. A fourth chapter considered Correggio and Benevenuto Cellini. A fifth chapter examined the work of Giacomo Barozzi, il Vignola and the commentary by Egnazio Danti. Chapter six considered the contribution of Guidobaldo del Monte. Chapter seven turned to the Bolognese school, namely, Guido Reni, Domenichino and Francesco Albani and a final chapter explored connections with scenography with Andrea Palladio, the Galli-Bibbiena family and Andrea Pozzo. Nielsen (1899) examined French contributions beginning with the school of Fontainebleau and Jean Cousin, with chapters on Androuet Du Cerceau and later painters (see below). Nielsen (1901), although focussed on later developments (see below), included a chapter on perspective in the sixteenth century German tradition (Dürer, Holbein). Nielsen was important because he explored perspective practice and theory in tandem as related problems. Prior to Nielsen, discussions had been limited mainly to the Florentine context. Nielsen revealed that perspective affected the whole of Europe including France, Germany, the Netherlands, Denmark and England. Nielsen was among the first to introduce reconstructions of perspectival vanishing points. Since these used simple engravings based on the originals as their starting points, their scholarly value was limited. Even so they prepared the way for the more technical analyses of Kern and a later level of precision which began with Carter (1953).

More general articles about the development of Renaissance perspective, which began to appear in the first decade of the twentieth century, emphasized perspectival practice. For example, Reymond (1905) focussed on architecture in paintings from the time of Giotto through to Filippo Lippi. In these discussions, Doehlemann and Kern, famous for their debates about Northern perspective (see below p. 59), played a role. Doehlemann (1907-1908) demonstrated that the theme of the Annunciation was particularly significant for the development of spatial effects in illuminated manuscripts as well as frescoes and paintings. Kern (1912) explored the painting practice that made possible Brunelleschi’s so-called first use of perspective. Kern examined a series of paintings with fish-bone perspective applied to ceilings by Simone Martini, the school of Giotto, Ugolino and Barna of Siena, Lorenzo di Bicci, an anonymous master of the Siennese schools, and Spinello Aretino, before considering Giotto’s Apparition to Fra Agostino and the Bishop (Florence, Santa Croce, 1325) which he claimed had all its lines on the ceiling converging to a central point. Since there were obvious differences between the treatment of ceilings and floors, Kern deduced that these paintings could not have been guided by a single theoretical concept of space: rather they must have been the product of painting
practice which he claimed went back ultimately to the the Pompeian frescoes of the late Roman period. In this view, the evolution of perspectival forms in the fourteenth century began with a revival of Ancient methods.

Kern also drew attention to a painting by Francesco Traini which tended towards a vanishing point and two examples by Lorenzetti, his *Madonna with Child, Angels and Saints*, the so called *Little Maestà* (Siena, c. 1340), and the *Annunciation* (Siena, 1344, pl. 7.3), the first known examples of a central vanishing point. Why then did the concept of a vanishing point not triumph sooner? Kern argued that there had been a mediaeval debate concerning the vanishing point and that Witelo, the leading mediaeval author on optics, had argued vehemently against it (cf. Kern 1904). He suggested moreover that this debate again went back to Antiquity when Lucretius had insisted on a single vanishing point while Vitruvius had argued against convergence to a point.

Grüneisen (1911) argued that the comparative study of techniques was to the history of art what philology was to the history of literature. He examined several characteristics of archaic art: the base plan reduced to an horizontal line, inverted perspective, plans with a vanishing point and bird’s eye perspective. These techniques, he claimed, were taken up in Byzantine art. Citing the work of Russian scholars such as Kondakoff and Likhatscheff, he claimed that these strands of Byzantine art had a seminal influence on the art of Cimabue, Duccio, Giotto and the Italian Renaissance in general. According to Grüneisen, Giotto knew both linear and aerial perspective! Müller (1913) gave his inaugural address as rector of the Technical University at Darmstadt *On the beginnings and nature of painterly perspective* in which he surveyed its history from proto-perspectival examples in Antiquity to the Renaissance, where he focussed on the contributions of Alberti, Piero della Francesca and Dürer, emphasizing links between mathematics and art which he believed to be of enduring importance to education.

Pittarelli (1918), provoked by a curious usage of the term perspective in the laws of 20 June, 1909 and 23 June 1913, reviewed the history of the term during the Renaissance, citing Alberti and Galileo and claiming that there were three principle meanings: the art or science of representing objects onto a plane or curved surface using central projection; the same things drawn or painted; natural views of objects which present themselves to the view of a landscape or the like.

Richter (1936), in an article which focussed on controversies concerning perspective in Antiquity (see above) cited Cennino Cennini’s description of a proto-perspectival method and mentioned in passing the contributions of Brunelleschi, Alberti, Uccello, Leonardo and Piero della Francesca, noting that Serlio believed Renaissance perspective to be in accordance with the doctrines of Vitruvius.

Nicco Fasola (1942), in a polemical article argued that perspective was not a discovery but rather an invention of fifteenth century Florence, that it had a basis neither in experiment nor in ocular experience, rather, that it was a product of a cosmological world view in which art, mathematics and science were seen as keys to certainty, while nature was conceived geometrically: hence the identification of the regular solids with the elements. Nicco Fasola noted that the academies had perpetuated the rules of perspective while failing to convey the historical context that had inspired it. That same year Nicco Fasola (1942) wrote an article on the “Development of perspectival thought in treatises
from Euclid to Piero della Francesca” summarizing developments in the mediaeval optical tradition (Ptolemy, Alhazen, Witelo, Biagio Pelacani da Parma), focussing on Alberti’s contributions in his On Painting and Elements of Painting as a prelude to the work of Piero della Francesca. A more thorough examination of Piero’s own contributions and a study of how this fitted into the aesthetics and cosmolological views of the Renaissance, (particularly Nicholas of Cusa), followed in Nicco Fasola’s (1942) introduction to her edition of Piero’s On perspective of painting.

Fiocco (1944), in an article entitled “The significance of perspective”, offered a brief outline of the history of perspective, claiming that it was “always quite other than systematic and an inseparable companion of intuition,” mentioning Brunelleschi, Uccello and Piero della Francesca, emphasising Mantegna, the illusionism of Veronese and Tiepolo, the negative contributions of the academy and finally Cezanne, who brought about the end of scientific perspective according to Novotny (1939). This Fiocco challenged, claiming that there had never been a scientific perspective in the sense that, from the outset artists had paid attention to intuition, and from the time of Giorgione onwards had given such attention to (subjective) atmospheric perspective that it could undermine the rigour of any linear rules.

Guerry (1951) summarized the evolution of the notion of space in a page noting that: “To express, three dimensional space using a surface of two dimensions: that is the problem of the painter and which he must resolve by means of a compromise. The history of this compromise, its hesitations, its affirmations, reprisals, omissions and negations, this is the history of perspective itself.” These ideas summarized those of her detailed study of Cezanne (see below). Sulzberger (1956) mentioned the historical contributions of Brunelleschi, Alberti, Piero della Francesca and Pélerin, but was more concerned with polemical claims about perspective being an indispensable element for the creation of a work of art and that the rules of perspective did not remove from the artist the possibility of choice since pictorial perspective was partly intuition and feeling.

Francastel (1951), in Painting and society. Birth and destruction of a plastic space. From the renaissance to cubism, described Brunelleschi as the originator of perspective in the context of architecture; suggesting that his panels were more to “permit a practical study of the plays of light than to realize an exemplary work,” claiming that these principles were then applied to sculpture by Donatello, whose David was “conceived not as a massive block, but as a place of intersection of geometrical plans which correspond to the axes of movements.” Francastel insisted that Masaccio was not the equal of Brunelleschi; that his work in the Brancacci chapel was closer to the ancient and mediaeval comic scene in theatre than it was to Florentine streets (cf. the conclusions of on p.** below); and that his colleague Masolino and his contemporary Angelico deserved more credit than they were generally given. The invention of Brunelleschi, claimed Francastel, “at first only appeared as a revolution in the domain of reconstruction..... The first artist who had the revelation of the miracle which passed to the hands of artists is Uccello.” Francastel reviewed the paintings of Pietro d’Arezzo, Andrea del Castagno, Bicci di Lorenzo, Sassetta, Domenico di Bartolo and Starnina to claim that linear perspective was but one more method along with other alternatives such as cavalier perspective. Indeed he claimed:
This discovery, this system, to the extent that it only consists in the reduction of the point of view to monocular vision and in the choice of a unique vanishing point situated at the back of the picture, to the extent that the person who uses it does not suspect (knowing) whether the discovery of a new technique does not presuppose the existence of certain laws of that spirit, revealing a new ideal, is of an application more limited than many others which had appeared towards the end of the fourteenth century in an epoch which one very wrongfully regards as ensconced in academicism.... Ergo linear perspective was not at all the most widespread nor doubtless that which seemed most to take account of the current aspects of the universe."  

Francastel claimed that the first generation of perspective artists had died by 1450; that the second generation spanned from 1450-1480 and that the third included Ghirlandaio, Signorelli, Perugino, Verrocchio, Pollaiuolo and Carpaccio. Theoretically perspective implied an adoption of a true representation of things by uniting their size and scale. He noted, however, that this did not apply to Gozzoli’s Journey of the Magi (Florence, Palazzo Riccardi), or the Mystic Marriage of the Virgin and the Transfiguration by Raphael or a number of other major paintings. Leonardo, he claimed had two meanings of perspective whence, “one will readily conclude”, wrote Francastel, “that even for contemporaries, the new system never had the appearance that one now lends it of being a plastic representation of the external world on a plastic screen in two dimensions”.

Thus perspective was not a constant law of the human spirit but rather “a moment in the history of ideas of space.” Perspectival space was in conflict with one of the major subjects of research at the time: “extension. It is through an extraordinary distortion that one has come to say and believe that the linear projection of space on a plane surface departing from a system of geometrical coordinates brought to a single point led to the representation of open space.” There was, insisted, Francastel something inherently contradictory in perspective. On the one hand it was theoretically about open space: practically it was about the construction of closed boxes. In the second part of his book he described the steps leading to the rejection of this approach (see below p.67*).  

Francastel (1967), returned to these themes in his influential Figure and place. The visual order of the Fifteenth century, in which he greatly developed his notion of visual images as a kind of language. He claimed that perspective (255):

> generates, among other processes, a differential organization of spaces, a certain implantation of the figures takes them form the interior space of the picture and places them at the intersection between the figurative space and the space of the spectator....The genius of Masaccio’s invention is not in having used form-colour to clothe a human figure in a space not identifiable with the figurative plane of the fresco, but rather in having used a technique that was already universally known to render manifest certain representative ideas of his time....

He insisted that perspective did not entail the discovery of immutable laws of nature. Rather, it was (255): “the consequence of a transformation of the mental sets of a given milieu.” At the same time Francastel suggested that there were three degrees of comprehension, signs, structures and orders and concluded that (345):
Linear perspective constituted only one of these imaginary frameworks, one of the justificatory structures of the new order of significations. It is not perspective that rendered concrete the true invention, the key to the renewal of painting and of the culture of the time. It certainly played a role but it only constitutes one of the means to which artists wishing to take part in the speculations of all the moderns had recourse. Siebenhüner (1954), in a published lecture, claimed that to understand the development of the theory of perspective in the Renaissance, mediaeval optics was meaningless and insisted instead that five other factors were crucial (129): the use of the visual pyramid as a means of perception; the parallel axiom of euclid’s *Elements* for the drawing of orthogonals; the corollary similarity proposition for the drawing of transversals, the introduction of the projection plane and the distance pont construction as construction regulator for the foreshortening factor. A subsequent discussion suggested that perspective was no guarantee for great art and therefore concluded that it had a relative value.

Gallet, in an important thesis (1956), reported as an article (1959), examined the historical origins of linear perspective, noting the role of mediaeval optics, the role of the University of Padua, with which Alberti, Toscanelli, Nicholas of Cusa, Biagio Pelacani da Parma and Giovanni Fontana were connected and the nexus of Florentines which included Manetti, Toscanelli, Alberti and Brunelleschi. This led to an outline of major fifteenth and sixteenth century theorists. Part two focussed on artistic practice beginning with the Tuscan context, Piero della Francesca’s influence, the art of the great decorators and scenographers, (Pintoricchio, Raphael, Serlio, Palladio and Scamozzi) ending with a chapter on perspective North of the Alps. That which set this study apart from others was Gallet’s painstaking attempt to understand the intellectual circles, the social climate one would say today, that made possible the rise of perspective.

Gioseffi (1957), in a significant article that also considered questions of perspective in Antiquity (mentioned above p. 39*), reviewed the use of space from Cimabue, through the Northern Italian painters, Avanzo and Giusto de Menabuoi in order to challenge the spatial schemata proposed by White (1957). Where White saw a radical break between the work of Giotto and Brunelleschi, Gioseffi saw a clear continuity. Gioseffi challenged White’s interpretation of Brunelleschi’s experiment, suggested that White’s claims concerning synthetic (i.e. spherical) perspective, could be accounted for more easily by the use of curved mirrors. In the latter part of his article, Gioseffi analysed Paolo Uccello’s use of perspective in the *sinopia* for and the finished *Nativity* (Florence, San Martino alla Scala); in predellas showing the *Profanation of the host* (Urbino, Galleria nazionale delle Marche); in the fresco of *John Hawkwood* (Florence, Santa Maria Novella) and in the *Stories of Noah* (Florence, Santa Maria Novella, Chiostre Verde).

Gioseffi (1957), further developed these ideas in his book entitled *Artificial perspective* which, (as already seen above) covered the whole history of the subject from Antiquity, through the Middle Ages to the Renaissance. In Gioseffi’s interpretation there were two independent strands of development, one based on spatial intuition, the other on scientific interest, which were first integrated by Brunelleschi. Gioseffi acknowledged the importance of Sanpaolesi’s (1951) attempt to reconstruct the historical context of
Brunelleschi’s work, which drew attention to the role of medieval optics (e.g. from Alhazen to Biagio Pelacani da Parma) and suggested that this tradition might have provided the impetus for his use of the perspectival window (velo). Gioseffi rejected this interpretation. He suggested instead that Brunelleschi painted directly onto the mirror and that his decision to do so might have been inspired by a study of Ptolemy’s work on mirrors.

Panofsky had claimed that Alberti did not have knowledge of the distance point. This Gioseffi challenged. He claimed that the distance point was neither Nordic in origin, nor discovered by either Piero della Francesca or Giotto. It derived, claimed Gioseffi, from Brunelleschi’s stereometric method. Gioseffi re-examined the perspectival method found in Gauricus (1504) and went on to challenge the claims of Brockhaus (1886) that Gauricus’ methods were similar to those used by Mantegna in the Eremitani Chapel at Padua. An attack on White’s (1957) claims concerning curvilinear perspective followed. According to Gioseffi there was no similarity between a convex mirror and the curvilinearity of the retina. Moreover, he insisted, we do not see things as they are seen in a convex mirror. Even so Gioseffi was convinced that curved mirrors had been popular in the Renaissance. Gioseffi also re-examined Leonardo da Vinci’s distinctions between simple and natural perspective, concluding that Leonardo had been the (119) “first to have an exact notion of the spherical optical image and of the non-identity between perspectival and ocular image”. Gioseffi touched briefly on the origins of Galli-Bibbiena’s angular perspective and concluded his book by voicing diffidence concerning the concept of social space as developed by Francastel. Gioseffi (1958) summarized these findings in an article and subsequently in two entries on “Optical concepts” and “Perspective” in the Italian version (1958) of the Encyclopaedia of world art, an English version of which appeared later (1965).

Wolff (1958), offered a five page history of perspective from the stone age through to the seventeenth century. Wolff criticized Poudra (1864) for having limited himself only to perspectival texts, claiming that it was important to include the evidence of paintings and drawings as well. Wolff’s history focussed on Giotto, Brunelleschi, Alberti, Viator and Dürer, mentioning the later contributions of Guidobaldo del Monte, Stevin and Desargues. Gioseffi (1961), in a polemical article, offered a summary history of perspective in terms of calculation and science. He challenged the ideas of Hauck and Panofsky, claiming that there was a confusion between perspectival representation and retinal image. Gioseffi was particularly critical of Francastel in his Painting and society (195**) and his Style of Florence (196*), who had claimed that the origins of Italian perspective might be found in Ghent or along the Paris-Padua axis. Gioseffi argued that a clear distinction was needed between the empirical naturalism of the Flemish and the scientific realism of the Florentines. He insisted on the seminal role of Brunelleschi in this context; claimed, on the basis of Uccello’s sinopia, that the distance point was also an Italian contribution and suggested that Piero della Francesca was not an innovator, but rather one who carried the Florentine approach to its logical conclusions. Leonardo he claimed had been the most important theorist of perspective. From the mid-sixteenth century onwards perspective had passed from into the hands of mathematicians, and the Renaissance links between art and science came to an end.
Sanpaolesi (1962), in a basic book about Brunelleschi (see Appendix 3), published a tracing of the sinopia of the *Trinity* by Masaccio (pl. 8.2), which was important because it drew attention to the role of preparatory drawings in early perspectival works, and re-opened the question of the fresco’s perspectival reconstruction (pl. 8.3). Guerrisi (1962), a professor at the Academy of Fine Arts, (Rome), reacting to the work of Cassirer, Panofsky and Francastel argued that artistic space was independent from the geometrical and symbolic space of philosophers, that the power of Piero della Francesca’s heads lay not in their geometry, but rather in his power of representation.

Danielowski (1962), offered a brief outline of the history of perspective which he characterized in five steps which were preceded by aspective representation in which no clear determination of boundaries or rules were evident (Early Egyptian art). A first step towards perspective introduced horizontal lines which bounded the picture above and below but left open the sides (Egyptian art). A second step introduced boundaries to the right and left (Pompeian art). In a third step this bounded space was more narrowly defined and tended towards an axial perspective (Late Roman art). In a fourth step this led to a vanishing point with respect to one plane, usually the floor as in Lorenzetti’s *Annunciation* (Siena, 1344). An interim step led to this principle being applied to each of the sides independently as in Jan van Eyck’s *Arnolfini Portrait* (London, National Gallery, 1434). In a fifth step this principle was applied to all four sides and co-ordinate to produce a single vanishing point as in Petrus Christus’ *Madonna with Saints Jerome and Francis* (Frankfurt, Städtisches, 1457).

Flocon (1963) wrote an article giving a “Succinct history of perspective” in which he linked perspective with the problem of projection, noting that the psychological projections of “primitive” persons on the walls of caves such as Altamira marked a first step. The development of frontal perspective, scenography in Antiquity, mystical and Gothic perspective in the Middle Ages, which led to imitation of Nature in the Renaissance, the development of anamorphosis, perspectival machines and methods of spherical perspective. These themes were developed in book form with René Taton in the *What do I know?* (*Que sais-je?* 1050) series which offers one the most accessible histories of perspective to date. While focussing on Renaissance examples it included both predecessors, mathematical connections with projective geometry and modern developments in curvilinear perspective.

Doesschate (1964), an ophthalmologist, produced one of the most succinct surveys of technical aspects of perspective, including marginal distortions, anamorphosis, visual size constancy; with significant comments on the history of perspective: Antiquity, early Christian and Medieval, and Renaissance, with sections on Alberti, Uccello, and Piero della Francesca. While he introduced practically no new material, his masterful summary and synthesis makes this perhaps the best short introduction to serious debates in the field.

Parronchi (1964) re-published a series of earlier articles, (which have been considered above, p. 51*) in his seminal book *Studies on sweet perspective* (*Studi su la dolce prospettiva*), which included a re-construction of Brunelleschi’s first perspectival demonstration (pl.10.1), and remains one of the basic works in the field.
Chastel (1965) published two important books which, from our point of view, are most notable for the way in which they make light of the role of perspective. A first of these, *The great atelier of Italy*, focussed on the importance of the artistic workshops (*botteghe*) and concluded with a section on the power of style. An index referred to illusionism, sfumato and chiaroscuro, but not perspective, as aspects of style. Indeed perspective was mentioned only briefly as a technique which after the time of Masaccio, allowed one to: “organize space, distribute figures, and stabilize hierarchies between them. A slight lowering of the horizon exalted the figure. The progressive diminution of meeting points permitted the methodical insertion of useful details in the intervals of the anterior planes.” A second book, which was later retitled *The centres of the Renaissance*, had the same subtitle as its companion volume: *Italian art 1460-1500* and was an important contribution because it drew attention to other centres. The renaissance was not just about Florence: it was equally about Padua, Parma, Ferrara, Modena, Mantua, Pavia, Urbino and Milan. This work included a chapter on “Intarsia, geometry and perspective”, in which he argued that before before it was taken up by painters, perspective was used by artisans who produced marquetry to create both pure geometric ornament and mathematical space through a use of illusionistic articulation of volumes and lines. Chastel cited examples from Parma, Padua, Genoa and Montecoliveto Maggiore. Chastel’s illustrations included but did not discuss other important examples of perspective such as Donatello’s Martyrdom of Saint Lawrence (Florence, San Lorenzo, pp. 96-97), Bramante’s illusionistic altar in Santa Maria presso San Satiro (135), the *Last Supper* in the versions of Ghirlandaio and Leonardo (224-225) and the *Mystic Marriage of the Virgin* by Perugino and Raphael (298-299). In Chastel’s approach perspective remained mainly an instrument of ornament. Paolucci (1966) gave a significant survey of the dissemination of perspective in a popular series (*I maestri del colore* 257).

Klein (1970), in *Form and the intelligible*, included four essays on perspective (republished). A first of these offered a critical review of secondary literature in the years 1956-1963, notably Brion-Guerry, Giosseffi, Maltese, Parronchi, Pedretti, Sanpaolesi and White. A second, written with Henri Zerner, entitled *Vitruvius and the theatre of the italian Renaissance*, suggested that this period introduced two new languages for the theatre: perspective and archaeological reconstruction which humanists attempted to reconcile. Here he drew attention to Sangallo’s sketches in Verulanus’ edition of Vitruvius. and outlined some of the key moments in the development of Renaissance stage scenery (cf. below p. *). A third explored the interplay of urbanism and utopianism from the time of Filarete to Valentin Andreae. A fourth on *Humanists and science* examined critically the claims of Zilsel about early modern science being caused by a combination of humanist and technical strands at the turn of the seventeenth century.

Harnest (1971) in a work mainly concerned with reconstructions of Renaissance art (see below p. **), offered a synoptic view of key developments in map form (fig. 8). Franchini-Guelfi (1973) contributed a significant appendix on “Organizaton of the image in the drawing of a plane: perspective techniques”. Da Costa Kaufmann (1975) presented a useful brief history of the perspective of shadows, exploring the contributions of Alberti, Leonardo and Dürer with brief mentions of later works, the *Codex Huygens*, De Caus, Marolois, Aguilon(ius), Accolti, Dubreuil, Bosse, Desargues, Hoogstraten and Grimaldi.
A useful textbook with Danish translations by Johansen and Marcussen (1978) on *Space perception and space construction* contained excerpts from basic texts from Antiquity to the Renaissance. These included passages from Plato’s *Politics, Theaitetos, Parmenides*, and the *Nomoi*; Aristotle’s *De memoria et reminiscencia*, Euclid’s *Optics*, Vitruvius, Ptolemy, Damianus, Proclus, Alhazen, Bacon and Witelo in the early period. Fifteenth century individuals included Ceninni, Manetti, Vasari, Alberti, Ghiberti, Filarete, Piero della Francesca, Francesco di Giorgio Martini and Leonardo da Vinci. Sixteenth century theorists included Gauricus, Pélerin, Dürer, Johann II von Pfalz Simmeren, Serlio, Commandino, Barbaro, Jamnitzer, Vignola and Lomazzo.

Sinigalli (1978) produced a significant Italian edition of Stevin’s which began with useful reconstructions of the chief construction methods in the fifteenth and sixteenth centuries, notably, Brunelleschi, Alberti, Piero della Francesca, Leonardo da Vinci, Gauricus, Pélerin, Durer, Serlio, Vignola (cf. pl. 45-46), Commandino, Guidobaldo del Monte and Kepler. Sinigalli (1981) went on to do an analysis of Borromini’s perspectival alley in the Palazzo Spada, the technical brilliance of which, some would claim, exceeds the evidence of the problem. Since then he has become the leading Italian editor of major treatises on perspective, including Guidobaldo del Monte (1984), Ptolemy’s *Planisphere* (1992), Commandino’s *Planisphere* (1992) and his *Perspective* (1993). These works do an immense service of making accessible important sources in translation (into Italian).

For the field of perspective studies undoubtedly the most important single event thus far was the first world congress: *Renaissance perspective. Codification and transgressions* (1977, published 1980). Originating as an idea of the late Eugenio Battisti, but painstakingly organized and edited by Marisa Dalai Emiliani (1980) this brought together for the first—and to date only—time most of the leading scholars in the field. Volume one of the conference proceedings had three sections: 1) a preliminary section raising questions concerning the boundaries of the field; 2) perspectival practice; 3) treatises and questions of theory and method. Section one began with a stimulating speculative essay by Gioseffi on the relation of perspective to semiology. Becchi and Riva reported on their work in spatial analysis of population and raised questions how new approaches to geography, demography and territorial analysis were affecting our traditional notions of perspectival space. Severi raised questions on the use of human figures in perspectival systems: namely, the problem of how perspective emphasizes spatial contexts which dwarf the size and visual significance of human figures.

Section two began with a significant article by Chastel on the contradictions (*aporeis*) of perspective in which he probed into the discrepancies between some of the high ideals initially associated with perspective and the way in which later commentators such as Vasari tended to dismiss it as merely a playful accessory. In a opening section on theory and practice Chastel noted that Alberti’s *On painting* was not written for practitioners, implying that the development of perspectival practice continued largely independent of theoretical treatises. Chastel raised questions about the function of perspective. Its purpose seemed to be to produce an objective image. Yet did it not accommodate itself to accredited compositional schemes? Was it not transformed by the painted scene? He drew attention to a curious paradox. While perspectival theory spoke of a spectator looking through a window into the picture, perspectival practice demonstrated the opposite, namely structures in which painted inhabitants regard the viewer. Hence the so-called spectator was less a viewer than a person viewed. The important thing in perspective, claimed Chastel, was not the lines going towards the horizon, but rather the buildings that acted as receptacles and the faces that they framed.
Albertian theory, he went on, had ignored the practical importance of categories or genres of painting. In sacred art, where the goal was an image of piety, space was reduced to nothing or nearly nothing. In narratives of miracles and historic episodes one found the same episodes in monumental cycles as in predellas. He claimed that both those who worked in marquetry and those painted scenes on marriage trunks (cassoni) treated scenes in the same way as social space. He questioned any necessary connection between the urban spaces of these marriage trunks and scenic illusion. In the final part of his paper, Chastel urged that it was simplistic to make equations such that perspective = logic = end of transcendence and the reduction of art to purely secular themes. He pointed out that the introduction of perspective which should have reduced paintings to a simple horizon line, often brought, especially in Ferrara, complex painted altars with their own internal scenes. He concluded that perspective, while clearly linking art and science in new ways was at the same time intimately connected with the ornamental and the intuitive thus producing new effects of the marvellous.

A second essay in the Congress proceedings turned to the question of origins: Lang suggested that Brunelleschi’s panels were related to the tradition of Vitruvian theatre. Angeli and Zini returned to the debate whether perspective was an invention or a discovery. A number of contributions examined unknown or largely unfamiliar material. Bora explored the role of foreshortened human figures in ceiling painting (quadratura). This was important because he demonstrated, (in a sense for the first time although Panofsky had published the *Codex Huygens* in 1940), that there was a considerable corpus of theoretical writings and drawings on the specific problem of foreshortened human forms and that these could in some cases be related directly to the extant evidence of painting practice. Equally significant was a paper by Shearman which compared two illusionistic ceilings by Correggio namely those in San Giovanni Evangelista and the Duomo in Parma and suggested their links with sacred dramas (sacre rappresentazione). Pochat focussed attention on a Northern Italian manuscript of architectural drawings with scenographic motifs (c. 1500-1520) now in the Louvre. Daly Davis drew attention to details of Carpaccio’s work on regular solids and related them to figures in manuscripts and published treatises. Mullazani was able to relate the spatial construction of Mantegna’s *Room of the Married Couple* (*Camera degli sposi*, Mantua) to a newly found literary source. Joost Gaugier discussed the role of Tuscan connections in Jacopo Bellini’s *Sketchbooks*.

With respect to post-Renaissance perspective, Marinelli examined Tintoretto’s use of space, while Zanini explored Klee’s deliberate transgressions of space in his avantgarde paintings. Battisti in a brilliant closing address drew on a whole range of sources ranging from Giovanni Fontana in the fifteenth to Oscar Schlemmer in the twentieth century.

A series of papers included reconstructions: four focussed on this. Robbiani proposed a reading of the fictive choir in Santa Maria presso San Satiro; both Polzer and a group of young scholars (Arese, Bonomi, Cavaliere, Fronza) analysed the space of Leonardo’s *Last Supper*; while Ciati offered reconstructions of a number of intarsia by the Lendinara brothers. Other papers used reconstructions to make further points. For instance, Sindona used reconstructions of Uccello’s frescoes to argue for links between perspective and a crisis in humanism. Arasse included reconstructions in his analysis of Masolino’s paintings, with a view to showing that some of his seeming errors in perspective were deliberate and had religious motivations. Similarly, Wakayama used reconstructions of Masolino’s works to discuss problems in the visualization of narrative (istoria). In section three, a proposed methodology for reconstructions, alas a-historical, was offered by Degl’Innocenti and Bandini (pl. 41-42).

Section three on the theoretical literature of perspective contained explorations concerning the theoretical origins of perspective. Reacting to Edgerton’s claims that Ptolemy’s geography was an important source for the (re-)discovery of perspective,
Veltman suggested that Ptolemy's work in astronomy was more significant, notably through his writings on the planisphere; a theme which Sinisgalli explored also in his discussion of Commandino's (1558) edition thereof. Saccaro Battisti focussed attention on uses of the camera obscura in an Italian manuscript of Alhazen (Vatican, Vat. Lat. 4595). This was all the more important because Battisti suggested the role of mathematico-geometrical and logical-ontological structures in mediaeval philosophy as premises for the discovery of perspective. This larger philosophical context was also examined in a penetrating paper by Kaori Kitao which examined the role of perspective in relation to optics and the camera obscura in order to explain the origins of Kepler's distinction between images which can be physically projected and measured (pictura) and those which cannot (imago). Pedretti touched upon the symbolic organization of space in Leonardo's drawings of knots.

In section two, the theme of anamorphosis was touched upon by Battisti, who demonstrated the results of Masters' computer program for reconstructing cylindrical, conic and spherical projection methods. In section three, Maltese took up the theme of curvilinear perspective in Leonardo da Vinci and related this to a surveying instrument by Baldassare Lanci--a topic to which Maltese (1978) returned when he challenged Pedretti's (1963) claims about Lanci's instrument and his interpretations of Leonardo da Vinci's approach to spherical perspective. Naitza's discussion of anamorphosis, while adding no new material, nonetheless raised larger questions.

Martinelli and Pino provided a survey of sources in Milanese libraries, a task which Olivato performed for libraries in the Veneto. An unpublished paper by Veltman, originally commissioned, but not published by Daedalus, re-assessing Panofsky's contribution a half century after the publication of Perspective as a Symbolic Form (1927), was the final paper in the book. Garriga (1978) published a survey of the conference in Spanish. The bibliography, originally planned as volume two of the congress has grown into the present four volume version.

At the world congress Vagnetti (1977), offered a magisterial survey of sixteenth century sources that served as a prelude to his subsequent (1979) critical (ragionata) bibliography. This bibliography was was much more than a list of books. Vagnetti provided comments concerning most of the works and was, as his title indicated, a "contribution to the formation of a rational idea, in its development from Euclid to Gaspard Monge." In his introduction, Vagnetti emphasized the universality of problems of spatial representation and suggested (25) that perspective in its technical sense should be considered both a discovery and an invention. A first section of his work considered elements of the phenomenology of vision (35-44) with texts on the principles of physical, perceptive, physiological, psychological and geometrical optics (45-95). A second chapter dealt with anomalous perspectival theories: the methods of Egypt and Mesopotamia, oriental pseudo-perspectival methods in Persia, India and the far East (95-108). A third chapter (108-154) turned to the contributions of classical Antiquity, with a brief discussion of vase painting, Plato’s position, Euclid’s contribution, the accounts of Lucretius and Vitruvius, the evidence of Roman wall paintings, the contribution of Ptolemy and subsequent authors: Galen, Theon’s Commentaries on Euclid’s Optics, Heliodorus of Larissa (Damianus), Proclus and Boethius. Chapter four focussed on the mediaeval period (155-194), noting the importance of Alhazen, Leonard of Pisa (Fibonacci); the Franciscans, Robert Grosseteste and Roger Bacon and John Peckham; Witelo, Henry of Langenstein, Nicholas Oresme, Blasius of Parma, Cennino Cennini.
Chapter five on the fifteenth century (195-280) marked the beginning of Part two on the modern age. Vagnetti began with a graphic reconstruction of Brunelleschi’s first (pl. 10.2) and second panels: assuming that he had used a ground-plan and elevation method and Alberti’s “abbreviated” method. Vagnetti linked Brunelleschi’s invention with his profession as an architect, and traced his influence on Donatello and Masaccio. Vagnetti drew attention to those who spread the principles of perspective: Ghiberti, Filarete, Francesco di Giorgio Martini; Piero della Francesca, the first codifier; Bramante, Leonardo da Vinci. Most earlier authors had focussed on one of these figures and attributed to them the glory of having invented perspective, such that there were camps in favour of Brunelleschi versus those in favour of Piero della Francesca. One of Vagnetti’s great contributions was to treat all these theoreticians as part of a cumulative tradition, thus making it clear that perspective was not some sudden event but rather a gradual development.

This approach continued in his sixth chapter on the sixteenth century (281-348) where he turned to how perspective spread throughout Europe, noting the role of Pélerin, of German authors (Dürer Ryff, Lautensack, Stoer, Lencker, Jamnitzer), and French authors (including the Italian Serlio who worked in France, Cousin, Du Cerceau). Vagnetti drew attention to the importance of Commandino for the scientific maturation of perspective; the rise of manuals (Vredeman de Vries, Cataneo, Vasari Jr. and Cigoli); the role of particular theorists (Bassi, the author of the Codex Huyghens, Lomazzo) and the rise of perspective as a science (Benedetti, and Guidobaldo del Monte).

Vagnetti’s next chapter on the seventeenth century (349-424) traced the contribution of the Low Countries (Aguilonius, Marolois and Hondius), the role of manuals (Sirigatti, De Caus and Ferdinando di Diano) and the emerging predominance of the French (Migon, Aleaume, Vaulezard, Desargues, Bosse); polemical debates (Desargues and Bosse versus Le Brun and Le Bicheur); optical-perspectival pastimes, i.e. anamorphosis (Niceron, Maignan, Dubreuil, Bettini, Kircher, Schott, Tacquet); the revival of scientific theories and empirical practices (Battaz, Contino, Gaultier de Maignannes, van Schooten, Guarini, Milliet Dechales, Ozanam, Le Clerc, Troili, Scheiner, Moxon and Hartnaccius), with a special section on Pozzo and the revival of experimentalism. Chapter eight focussed on eighteenth century developments (425-463), on the emerging scientific context (Lamy, Galli Bibiena, s’Gravesande, Amato, Taylor, his commentators, Hamilton, Kirby, Jacquier, Fournier, Highmore, Michel, Malton; special attention to Lambert; Karsten and Burja); the limits of illuminist experimentalism and the background to Monge. Part three included two brief sections without an introduction on the nineteenth (465-477) and twentieth (478-492) centuries.

There are some clear limitations to Vagnetti’s monumental work. The sections on the nineteenth and twentieth centuries are by no means comprehensive, but then, as the title indicates, they were not intended to be so. There are many spelling mistakes. But all these are minor shortcomings compared to the great contribution that he made. Vagnetti was the first scholar to view the entire history of perspective as a single complex whole, integrating a series of disciplines beyond his own specialty of architecture, namely: art history, optics, psychology, mathematics and science. He created a framework for understanding perspective not as a simple event that happened one day when Brunelleschi did his demonstration, but rather as a series of methods that developed
slowly in the course of several centuries. While future scholars may decide that a number of details in this plan need correction, the grand scheme he outlined assures for Vagnetti an enduring place in the history of perspective.

Salvemini (1984) studied the etymological history of vernacular Italian usage of the term perspective (prospettiva) during the twelfth and thirteenth centuries, which was reprinted in her book (1990). She drew attention (10) to a legal use in the late twelfth century, (although this became the late thirteenth century (22) in the next chapter), where perspectiva meant “view of a prospect”. The use of this concept was traced through the writings of Alhazen, Grosseteste, Bacon, Peckham and Witelo, before concluding that (15): “Perspective does not reproduce in this way, as it expresses aesthetically, merely a visual phenomenon. It establishes and determines the cognition of the view of a prospect.”

A second chapter explored the contributions of Levi ben Gerson, particularly with respect to his staff (baculus). Its transmission through a number of individuals was suggested, namely, Jacob ben David Yamtab, Simone di Covino, Emmanuel ben Iacob di Tarascon, Abraham Zacuto, Regiomontanus, Ser Filippo di Ugolino Peruzzi and Paolo dal Pozzo Toscanelli. Following a description of the instrument, it was claimed that (50):

"Constructed in this way an instrument similar to that used by Levi ben Gerson could apply to the visual pyramid defined by it, the formula of proportionality inverse to the distance and establish the relation of scales between the two aligned surfaces". A chapter entitled "Natural artifice of artists" explored differences (97) between Alberti who was concerned with a visual attitude and Gauricus who described a visual ideal.

A final chapter explored the background to Lorenzetti’s Annunciation in terms of architectural enclosures as painted space. Giotto’s Sermon to Onorio III (Assisi) and Simone Martini’s Death of Saint Martin (Assisi) were cited as early examples. Martini's connections with the court of the Popes, Avignon) was claimed to play a key role in changing the function of this motif from a purely ornamental one such that "the fresco regains in its proper drawing the architectonic wall, reducing it visibly to an inarticulated support". Subsequent examples by Giusto de Menabuoi (1370) and Fra Angelico (1427) were given. An appendix reconstructed the steps used in Alberti’s method (132-155).

Thuillier (1984), summarizing the ideas of Panofsky, Gadol, Edgerton and Baxandall, was concerned with links between perspective and space, arguing that art was a preparation for science and citing Galileo: “The most artistic ‘imitation is that which represents three dimensionality in its opposite which is a plane surface.” Thuillier emphasized the need to see perspective as “a new way of seeing the world, of sensing its organization, of imagining its structures.” He argued that “research into a homogeneous and unified space corresponded to a general preoccupation of advanced societies at the time.” He claimed that the development of practical mathematics helped one to understand “why and how the view taken of things transformed itself, geometricized itself in some way. To discover proportions, identify triangles, cones and cylinders was from now on a kind of cultural habit.” He went on to suggest that “topography, cartography, and perspective appeared as branches of a general science of spatial representation.”
Thuillier concluded that “classic linear perspective, in spite of its interest, cannot be considered as a system endowed with an absolute value. It is convenient, it gives a certain satisfaction to the intellect but other systems are possible such as the so-called curved or curvilinear perspective the principles of which have been known a long time.” Veltman (1986), in a basic book on Leonardo, showed that perspective evolved gradually in the course of the Renaissance, and that Leonardo’s contribution lay in the introduction of a systematic experimental approach (cf. pl. 11-12).

A major book by Kemp (1990), *The science of art. Optical themes in western art from Brunelleschi to the present*, provides the best generally accessible survey on the history of perspective in recent years, with three main sections on perspectival principles, machines and colour respectively. One of the very attractive features of the work is that Kemp provides reconstructions of a number of key frescoes and paintings by the two key practitioners of proto-perspective Giotto, and Lorenzetti, and many of the principal artists in the fifteenth century including Brunelleschi, Masaccio, Alberti, Ghiberti, Piero, Uccello, Gauricus, Mantegna and Leonardo. These reconstructions are so elegantly presented that only the most attentive of readers will be aware that there are considerable controversies as to how such lines are to be drawn. For instance, there is no mention of three contending theories (Panofsky, Grayson and Parronchi) concerning Alberti’s method in his treatise *On painting*.

With respect to the sixteenth century Kemp begins with Dürer and Cousin before examining links between illusion and mathematics in Italian quadratura: e.g. Raphael, Forbito, the Rosa brothers, Laureti, Mascherino, Sabbatini, Vanosino, Bassi and to Carlo Urbino, the presumed author of the *Codex Huygens*, Vignola and Lomazzo as well those who established new links between mathematics and science, notably, Commandino, Benedetti, Guidobaldo, Galileo and Cigoli. Seventeenth and eighteenth century authors include examples from Belgium (Rubens, Aguilonius), Spain (Velazquez), Netherlands (Saenredam, Houckgeest, Hooch, Hoogstraten), France (Desargues, Bosse, Dubreuil, Poussin, De la Hire, Le Sueur); Italy (Colonna, Mitelli, Zanini, Pozzo, Galli da Bibbiena, Canaletto) and Britain (Ditton, Taylor, Hamilton, Kirby, Malton, Turner). Non-experts might assume that this list is both the result of the author’s personal research and exhaustive. Some may note that problems such as quadratura (Sjöström) and theorists who have been studied in detail by others such as Commandino (Sinisgalli), Cigoli (Camerota), Saenredam (Ruurs) are given more detailed treatment. Indeed experts in the field will recognize that Kemp has provided a remarkable survey of secondary literature of the past decades in particular and the past century in general.

This applies also to the second section of Kemp’s book which is devoted to a series of specialized perspectival instruments and machines (De Keyser, Amman), as well as the perspective window, camera obscura and camera lucida. A further chapter examines devices connected with what he terms artificial magic, namely, peep show, zograscope, panorama, stereoscope, stroboscopic disc, zoetrope and photography. A chapter on seeing, knowing and creating considers the work of eighteenth century theorists such as Lambert, Monge, Valenciennes, Adhémar and Choisy and examines some of the precursors of curvilinear perspective: Parsey, Herdman, Hauck, Ruskin. Section three on colour falls outside the scope of the present study. Two appendices deal with the basis of the perspective construction and Brunelleschi’s demonstration panels. A revised version
(1992), which corrected minor typographical errors, assures that Kemp will remain an important reference work.

Elkins (1995) in the *Poetics of Perspective* claimed (xi) that perspective was "more a collection of rational methods than a 'rationalization of sight'". His interest lay in tracing how "the recession of perspective as a method was paralleled by the growth of perspective as a metaphor, a powerful concept for ordering our perception and accounting for our subjectivity". While tracing the history of perspective as a metaphor he added little in terms of new sources. Useful, however, was his use of this evolution as a means of relating traditional (positivistic) historical analyses (e.g. M. Kemp) and more recent fashions in scholarship (e.g. Damish, Bryson, Lacan), thus showing connections between what some have assumed were mutually exclusive approaches.

1. Workshop constructions  Unwritten late medieval practice:  Principal point, diagonal, bifocal, monofocal constructions
2. Distance-point  Pélerin, Vignola
3. The *costruzione legittima*  Alberti
4. Reformed workshop methods  Inaccurate mixtures of classes 2 and 3:  Filarete, Gauricus, Ringelbergius; also in Serlio and Leonardo
5. Visual-ray Method  Plans and elevations, with lines drawn to a center of projection  Vignola, Piero, Cataneo, Sirigatti, Cousin, Barbaro, Commandino, Benedetti, Guidobaldo del Monte
6. Circumscribed rectangle method  Rectangle with triangular foreshortened version on top:  Alberti, Piero, Cousin, Barbaro, Benedetti, Serlio, Guidobaldo del Monte
7. Direct method surrounding  A plan below a ground line, without the use of a rectangle:  Vignola, Du Cerceau, Ringelbergius
8. Vanishing point method  Based on the generalized law of the vanishing point:  Guidobaldo del Monte
9. Inverse method  Reconstructing plans from perspectives:  Leonardo, Guidobaldo del Monte

Fig. 10. Ten classes of Renaissance perspective according to Elkins (1995), p. 87.

A first chapter outlined the scope of modern perspective including a metaphor for vision, pluralism, states of mind and epochs of art. Elkins began by tracing the early history of perspective in the Renaissance, noting that it was used in parts of paintings and not entire paintings or ways of making paintings. Elkins therefore preferred to speak of Renaissance perspectives and claimed that there were at least ten classes thereof (fig. 10 ). All of these, he claimed sought to establish a ground for perspective that was independent of mediaeval optics, was more generally valid and more logical.
Method based on optics, surveying (vision) window and thread (legitimate construction) Brunelleschi?
Alberti, *On Painting*, Bk.1
Filarete, *On Architecture* (method two)
Piero, *On Perspective*...
F. Di Giorgio Martini, *Treatises* (method two)
Dürer, *Instruction*
Serlio, *Architecture Bk. II* (method two)
Danti, Vignola, *Two Rules* (method two)

Method based on geometry (mathematics) proportion theory (distance point construction)
Alberti, *On Painting*, Bk.II,
Filarete, *On Architecture* (method one)
Piero, *On Perspective*... (method one)
F. Di Giorgio Martini, *Treatises* (method one)
Dürer, *Instruction*
Serlio, *Architecture Bk. II* (method one)
Danti, Vignola, *Two Rules* (method one)

Figure 11. Summary of the two chief methods of perspective in the Renaissance.

1. Distance-point   Vanishing point method
   Direct method
   Circumscribed rectangle method
2. The *costruzione legittima* Mechanical methods
   Inverse method
   Visual-ray method
3. Workshop constructions Unwritten late medieval and renaissance practices

Fig. 12. Another way of looking at Elkin's classes.

While Elkins is right in reminding us that the notion of a single method of Renaissance perspective is an invention of later historiography, his proposed classification is not quite as unproblematic as it may at first appear. It is true that Renaissance authors were very much aware of alternative methods. Guidobaldo del Monte listed no less than 26. On the other hand, throughout the fifteenth and sixteenth century authors consciously spoke of two main methods. Veltman (1996) has therefore offered a rather different outline of these two methods, suggesting that as they evolved their relative importance shifted (fig 11).

If one accepts this model then Elkin's classes can be greatly reduced. Since, in the absence of written documents, we cannot know precisely what the much vaunted "workshop-methods" were, it is even open to question whether his categories 1 and 4 should be termed methods (fig. 12). Whichever way we read the evidence Elkin's point that Renaissance perspective was monolithic neither in theory or practice is important.
A chapter on the practice of perspective turned to demonstrations of skill, examples of play, notably eccentric vanishing points as in Uccello's Profanation of the Host (Sources, pl.) or Tintoretto's Removal of the Body of Saint Mark and what he terms anti perspective in Northern intarsia. A third part of the chapter examined arcane versions: Dürer's use of perspective in Melancolia, Holbein's anamorphic skull in the Ambassadors and tendencies toward indecorum in facade painting as in Holbein's Design for the Dance House (Haus zum Tanz, formerly Basel). While one of Elkins basic points was that perspective never clearly fit within any set of disciplines, his chapter on such attempts focussed mainly on curvilinear variants. A final chapter dealt with the fossilization of painting practice. An appendix on mathematics and perspective dealt briefly with Desargues' theorem, rabatments, cross-ratio, harmonic-ratio, projective and descriptive geometry.

Northern Art

Nineteenth century studies of Northern art remained sporadic. Von Berlepsch (1875) drew attention to the sketchbook, which had belonged to H. E. v. Berlepsch, of a sixteenth century architect with drawings mainly of fountains, tomb monuments and other architectural features dated 1573. The first decades of the twentieth century saw the emergence of a literature specifically devoted to perspective in Northern art. A context for this work was provided in a major article by Schmarsow (1904) on painting in the upper Rhineland and neighbouring territories in the period 1430-1460. He focussed on the work of three individuals, Konrad Witz, Hans Multscher from Ulm, and Lucas Moser from Weil, noting links with the Van Eyck brothers in the Netherlands, Master Broederlam and the Limbourg brothers in Burgundy as well as links with Italian art. Among the examples he cited was an Annunciation by Justus de Allemagna in the convent of Santa Maria di Castello in Genoa which was clearly based on the Ghent Altarpiece: northern space in an Italian context.

Kern (1904), in a fundamental and very controversial article argued that the Van Eyck brothers (q.v. in appendix 3, cf. pl. 36.1) must have known the principles of linear perspective although he claimed that Petrus Christus' Staedel Madonna and Child with Saints Francis and Jerome (1457) was the first to use perspective for an entire scene. This was challenged by Doehlemann (1904-1905, pl. 36.2; 1906). Doehlemann (1911) re-examined the history of spatial methods in early Netherlandish art. The Van Eyck brothers, he claimed, had used purely empirical methods; Rogier van der Weyden, by contrast had been more old fashioned, with no real interest in spatial effects. The Master of Flémalle, while still empirical had come very close to achieving such real spatial effects. Use of perspective had begun with Dirk Bouts' Last Supper (1464-1467). Petrus Christus and Ouwater had not had theoretical knowledge of perspective, nor in all probability either Memling or Geertgen van Haarlem. Gerhard David had been the first to draw correctly a foreshortened pavement. Exact constructions were also to be found in Lucas van Leyden and Jan Gossart, less so in Van Orley. It was however not until Vredeman de Vries (1560) that the principles of Italian perspective were fully understood in netherlandish art. Kern (1912) concluded that the discovery of one point perspective by either Jan van Eyck or Petrus Christus lay between 1436 and 1453. Doehlemann (1912) returned to the question of the brothers Van Eyck to which Kern again replied.
Kern’s views were accepted by Panofsky in his classic *Perspective as Symbolic Form* (1927).

Bombe (1911), examined in detail Justus van Ghent’s role in the studiolo and library of Duke Federigo da Montefeltre. This provided valuable material concerning interplay of north and south although it contained nothing on linear perspective in a technical sense. Jantzen (1912), in his book on *Seventeenth century Dutch Painting*, included a significant chapter on “The interior”. Mesnil (1912) examined northern resistance to concepts of regular space found in perspective, claiming that this stemmed from the realm of sculpture, particularly in connection with sculpted altarpieces, the discontinuity of space of which derived from medieval mystery plays, specifically those connected with the holy sepulchre. This made all the more interesting Kern’s (1912) findings that Van Eyck’s paintings had a particular connection with the holy sepulchre. Mesnil (1932) returned to the debates of Doehlemann and Kern arguing that there they had more in common than at first appeared: that an essential characteristic of early netherlandish art was a convergence towards a vanishing area rather than to a single point and that this characteristic was already clearly evidenced in the Master of Flémalle’s *Donor with Saint John the Baptist and Saint Barbara seated*, two wings of an altar executed for Heinrich van der Werl (Madrid, Prado, 1438). He argued that Northern art had developed independently of Italy, that its interests in space prepared it for Italy’s solutions in terms of linear perspective, but that there was no evidence of direct Italian contact in the first half of the fifteenth century.

Kern (1937), in a synthetic article, returned to his earlier themes but also added some new suggestions. Having noted that Ambrogio Lorenzetti’s *Annunciation*, (Pinacoteca, Siena, 1344), introduced the first known vanishing point for a pavement in a painting, Kern pointed out that this proto-perspectival method recurred in Dijon in the work of the Burgundian Master, Broederlam, and since Jan Van Eyck was in the employ of the Burgundian court, Burgundian artists from the circle of Broederlam would have acquainted him with this method. Kern surmised that Avignon would have been an obvious intermediary in the transmission from Siena to Dijon. This suggestion becomes the more interesting when it is recalled that from 1340 to 1344, i.e. the same time that Lorenzetti was doing his painting, Simone Martini was at Avignon establishing an Italian-French connection (see below p.117*).

Oertel (1940), in an important article on the origins of preparatory drawings in relation to monumental fresco painting in Italy, inadvertently drew attention to the importance of such drawings for the spread of Italian motifs to the North. In the Baroncelli chapel of Santa Croce, Taddeo Gaddi had depicted a *Presentation of the Virgin* with a particularly impressive proto-perspectival temple. This theme was taken up by the Master of the Rinuccini Chapel in Santa Croce. A preparatory drawing ascribed to the same Master now in the Louvre, may explain why a very similar treatment of the same subject should occur in the *Très Riches Heures Du Duc De Berry* (c.1420, f.5v). Pinder (1941) reconsidered the question of interior spaces. Pächt (1937 published 1952) examined German concepts of painting in the late Gothic and Renaissance, to explain why they did not focus on visual, perspectival aspects, why they maintained an abstract, ideographic conception and why there was a chasm between art and life in German art. Bouchery (1957-1958) returned to the question of development of the interiors in Dutch art,
claiming that in this branch of Dutch art it was particularly difficult to trace a continuity from the fifteenth to the seventeenth centuries; that after Aertsen and Beuckelaar in the mid-sixteenth century there was an hiatus in this theme, which began anew in the period 1615-1640, which laid the foundation of a new approach to interiors.

Danielowski (1960), analysed a series of Northern paintings in terms of their perspectival constructions including Jan Van Eyck’s Arnolfini Wedding (1434) and Madonna with the Chancellor Rolin (1435-1436); the Master of Flemalle’s Saint Barbara (1438); Konrad Witz’s Annunciation (c. 1440); claiming that the Madonna with Two Saints (1457) by Petrus Christus and Dirk Bouts’ Last Supper (1464-1467) were the first Northern paintings accurately constructed in terms of linear perspective.

Phillipot (1959), outlined basic differences between Flemish and Italian art. This was the starting point for a significant article (1962) in which he examined a crisis in South netherlandish art around 1480. According to Phillipot, there was an intellectualization of aesthetic consciousness which led to a new awareness of the painting as a painting as seen in the work of Vranck Van der Stock. There was a new emphasis on dynamic continuity between interior and exterior space which led to a return to narrative features. There was also a new interest in copies. Phillipot cited the work of a Follower of Rogier van der Weyden; the Master of the Legend of Saint Barbara; the Master of the View of Sainte-Gudule; the Master of the Abbey of Afflighem; the Master of the Legend of Saint Lucy, the Master of the Sibyl of Tibur, the Master of the Virgo inter Virgines ending with Geertgen tot Sint Jans and Hieronymus Bosch.

Levenson (1965), in a thesis on Petrus Christus and the Rational Use of Space, began with a history of scholarship listing the conclusions of Kern and Doehlemann and noting distinctions made by Bunim (1940) in order to suggest that Petrus Christus probably had “an awareness of a single vanishing point without an understanding of its mathematical basis”. This led to a chapter on the spatial solutions of Christus’ predecessors Jan Van Eyck, the Master of Flemalle and Rogier van der Weyden, and a further chapter on three spatial solutions of Christus himself in terms of the exterior scene, the portrait and the interior-exterior scene. This led to a rejection from the corpus of Petrus Christus of five problem paintings, namely: the Madonna and Child with Saints Barbara and Elisabeth of Hungary, and a Carthusian (New York, Frick Collection); Saint Jerome in his Study (Detroit, Institute of Fine Arts); the Friedsam Annunciation (New York, Metropolitan); Portrait of a Man (Los Angeles, County Museum); Madonna and Child (Turin, Galleria Sabauda). Levenson also claimed that the late paintings could be dated as follows: Staedel Madonna (1457), the Donor Panels (1457-1460) and the Dormition of the Virgin (1460’s). Castelnuovo (1966) provided an important brief survey of the interplay between Italian perspective and Flemish microcosm in a popular series (I maestri del colore 259), drawing attention to the role of René d’Anjou in early contacts and to a Master of Aix (Maestro di Aix) whose Annunciation (c.1440) marked the use of Northern space in southern France.

An important dissertation on Trompe l’oeil in Dutch seventeenth century painting by Burda (1969) identified a typology of principle themes namely, walls of letters, wall cabinets, music instruments, reproductions of artworks, hunting weapons and representations of hunting bounty, raising basic questions concerning their function, their
relation to other represented objects etc. Harnest (1971), offered a survey of early perspective (fig. 9), analysed a number of Northern paintings, particularly German ones in terms of their perspectival constructions. His enthusiasm for their posited precision sometimes imposed regularity not evident to other scholars. This approach was pursued in his Habilitation (197*).

Collier (1975), returned to questions of perspective in the art of Petrus Christus and Dirk Bouts. He began with a survey of the work of Kern and Doehlemann. He noted that Schöne’s (1938), monograph on Bouts had “pointed out that Bouts learned to handle perspective with some competence and used two examples...to illustrate the point”. Brand Philips (1967), had emphasized symbolic aspects of Van Eyck’s use of space. Upton (1972), had attributed Christus’ use of a unified perspective to an empirical development. Like Upton, Schabacker (1974), was interested in the aesthetic effects of perspective without explaining how it arose or what methods were used. Bazin (1952), had suggested that Christus might have travelled to Italy and learned the theory. Collier (1975,97) claimed that Christus:

seems to have been the first Northern artist to display both the correct use of the vanishing point for a single surface and for a unified perspective of several planes. Both of these discoveries probably occurred in the decade of the 1450’s. It is perhaps of some consequence that this occurred precisely during the years that the artist’s name vanished from the documents of Northern Europe, and that when it reappeared, the technique emerged in the work of Dirk Bouts. Bouts handled perspective in the same manner as Christus, but added the discovery of transversal spacing to art. His knowledge of perspective seems to have been passed on only to his son Albrecht and probably to Hugo van der Goes. Later in the century, even artists of the stature of Hans Memling and Gerard David showed ignorance of this knowledge, although David did display the first accurate oblique perspective even before the publications of Jean Pêlerin. At this point, perspective became common knowledge, and Gossaert, van Orley and other painters displayed a mastery of its use.

The final chapter of Collier’s thesis focussed specifically on the work of Christus and Bouts. Ragghianti (1977), in his book on Brunelleschi returned to these themes in a chapter entitled: Tuscany and Burgundy: Italian Perspective and Flemish Perspective, again showing reconstructions based on Kern, adding little in terms of new material. Myers (1978), in a speculative dissertation surveyed the origins of perspective with Brunelleschi and Masaccio and claimed that Petrus Christus probably learned about focussing the parallels of several planes in perspective from Antonella da Messina in 1456 and did not know the rules of correct perspective until 1457. Egner (1979), surveyed changes in painted architectural space in the work of Van Eyck, Bouts, Memling and Van Orley.

**Baroque (1600-1700)**

Nielsen (1899), examined the work of Poussin, the school of Versailles (Eustache Le Sueur, Charles Le Brun, and Pierre Mignard), the Royal Academy (Bosse and Dubreuil) and later painters (including Watteau and David). Nielsen (1901), explored famous practitioners of perspective in the Netherlands (Rubens, Rembrandt, de Hooch). Daniëls
(1978-1979), noted that the seventeenth century brought a shift from a use of architectural interiors as backgrounds for biblical scenes to their being represented for their own sake, and claimed that an analogous shift occurred with respect to trees. Govaerts’ Diana spied by Abraham was used as an example.

**Neo-Classicism (1700-1800)**

In his *Art of wash drawing*, Le Sieur de Gautier (1708), noted in connection with scenographic drawings that:

> Perspective being the foundation of these sorts of works one sees very few persons who apply themselves and who believe that they possess it perfectly because they are ignorant of perspective.... Cavalier perspective is so little to the taste of persons who are delicate in this regard that they do not even wish to deign to cast their eyes on it. I agree that it is a study that is fairly difficult to understand at first, and even if one possesses it in practice if one does not know how to reason about what one one is doing one falls into the most nasty accidents.

Nielsen (1899), outlined contributions of the English school (Hogarth, Reynolds, Gainsborough, Brook Taylor).

**Romanticism (1800-1900)**

Remarkably little detailed work has been done on the use of perspective in the nineteenth century. Nielsen (1901), included a chapter on Danish contributions (Nicolai Abildgaard, Gustav Frederik Hetsch and Cristoffer Vilhelm Eckersberg). Marcussen (1980), wrote a useful article on the evolution of perspective in France citing the work of Valenciennes (1800), Cloquet (1823), Thibault (1827), Adhémar (1836, 1870), Sutter (1859), and Dela Gournerie (1859). Marcussen (1983), pursued this topic of nineteenth century perspective in the context of Eckersberg’s art and his treatise on perspective, using this and the work of contemporaries to raise questions concerning the meaning of neo-classicism.

**Modern Period (1900-1990)**

El Lissitzky (1925), in an article on “Art and pangeometry” challenged the view that linear perspective was objective because it corresponded to the space produced by a camera, claiming that Western art assumed a convex lens whereas Chinese art assumed a concave lens and produced inverted rather than linear perspective. According to El Lissitzky linear perspective bounded space, made it finite and closed it in. This rigid Euclidean space had, he claimed, been destroyed by Lobachewski, Gauss and Riemann. The Impressionists had first begun to explode the inherited perspectival space (105-107):

> More important was the the experience of the cubists. They took the space enclosing horizon into the foreground and identified it with the painted surface. They developed what had been a solid surface with psychic characteristics (wallpaper covered walls etc.) and with elementary destructions of form. They built from the picture surface outwards into space. The final consequences of which are the reliefs of Picasso and counter-reliefs of Tatlin.

The Italian Futurists used another method. They took the apex of the visual pyramid out of the eye. They did not want to stand in front of an object but rather
in it. They took the unique perspectival centre, spintered it into perspectival
schards and spread it over the entire surface of the painting.

Suprematism placed the point of the finite visual pyramid of perspective at
infinity. It broke through the blue lampshade of the heavens. For the colour of
space it did not take the single blue ray of the spectrum, but rather the entire
entity, namely white. Suprematist space allows itself to be extended forwards
from the surface as well as backwards into depth. If we take the surface of the
picture as 0 then we can name the direction of depth as - (negative) and the
forward direction as + (positive), or conversely. We see that Suprematism sweeps
away the illusions of planimetric, two dimensional space, the illusions of three
dimensional perspectival space from their surface and has created the ultimate
illusion of irrational space through endless extendibility, depth, and foreground.309

Among twentieth century artists, it is well known that the the Cubists and other groups
were critical of and sometimes directly opposed to traditional linear perspective. Novotny
(1939), in an important book on Cezanne and the end of scientific perspective claimed
that perspective had died after Cezanne. The Swiss monthly magazine, Du,
devoted a
special issue (November 1949) to the problem of perspective. An opening essay by
Meyer surveyed examples by Gaddi, Pinturrichio, Mantegna, Asam, Galli-Bibbiena,
Hodler and Cézanne. Meyer claimed that there was a deeper reason for the demise of
perspective (22):

a lack of trust in the transparency of reality. Interest in reality as such has not
diminished. Knowledge of the appearances of the external world is greater than
ever, but man no longer feels himself at the centre of this external world. Its
perspectival arrangement in terms of a viewer standing firm at a given place has
become questionable. That is both the standpoint and the arrangement....Doing
without the perspectival order of objects in pictorial space signifies a dropping of
the claim that one wants to master the surrounding world conceptually or even to
maintain the dignity of the observer with respect to the surrounding world. The
personal observer, as eyepoint and horizon of the field of vision, is surrendered in
favour of an impersonal, anonymous objectivity. The painter no longer believes in
a binding structure of the world whereby external objects and observer are
simultaneously connected in the way that perspectival space encompassed both.310

Unlike the Middle Ages when there was at least a belief in God who held everything
together, there was no longer any ordering principle. Hence the chaos of modern
paintings which were often reduced to blobs of paint and lines. An article by Du Bois
Reymond in the same magazine linked perspective with orientation. Another by Marvil
was as its title suggested, a “Rhapsody” on perspective. Eichenberger’s “Notes without
perspective” considered paintings by Kandinsky, Gris and Miro and Dali. An article by
Pfister described a series of stereoscopic photographs.

Brion Guerry (1950), pursued this problem of the death of linear perspective in her
monograph on Cezanne, arguing that there was not one but rather there were a hundred
perspectives insomuch that there were a hundred ways of resolving the questions of three
dimensional space on a two dimensional surface. In her introduction she referred to the
allegorical perspective of the Greeks, mystical perspective of the Chinese, symbolic
perspective of the Middle Ages, rationalist perspective of the Renaissance, and a sentimental perspective of the Baroque. Hence each age had its expressions of space and perspective. (Brion-) Guerry identified clear steps in the development of Cezanne’s approach (9):

At first his visual field is a restrained space where the illusion of the third dimension is suggested by the curve. The point of view, which is not the point of conjunction of the vanishing lines is mobile. This is quite close...to the subjective spatial conception of the Greeks. Through a fairly artificial game of constructive combinations, Cezanne tries to stabilize an essentially moving composition, but he does not reach the point of homogenizing the spatial content, that is to say, the object and its container: the atmospheric envelope311.

This, claimed (Brion-) Guerry, was Cezanne’s goal in his early paintings when he was staying with Pisarro at Auvers in 1872. He then reached a first equilibrium whereby the restrained, unstable visual field of the Modern Olympia became the enlarged, more peaceful space of the House of the Hanged Person (Maison du Pendu). His spatial research using colours brought an impressionist period, then a constructivist period (1878-1892). This brought with it a formal simplification which stiffened and denaturalized the original model such that the image moved away from its concrete base and tended towards pure abstraction thus foreshadowing the activities of the Cubists who took these same principles a degree further. In his late period Cezanne returned to impressionism of a more pacified and stable type, finding a new equilibrium between the rigour of form and the fluctuations of light. (Brion-) Guerry concluded that in the late paintings of Cezanne (179):

the visual field is thus expanded by all that which is evoked without being said. The horizon does not close at the visible limit of a perspective construction such as would occur if, with this construction the figured representation expressed itself in its fullness. The spatial building to the extent that one prolongs it within the bounds of a pre-established constructive schema, does not contain the totality of expression of the image. This is only achieved through the extensions imposed by the imagination of the viewer who dare not refuse it at the risk of ruining at the same time the evocation of the object. Thus the spatial field is rendered limitless: more precisely, one would have to say that it has no limits other than the bounds of creative freedom.312

According to this interpretation Cezanne’s spatial experiments led him to recognize the importance of what Gombrich subsequently termed the beholder’s share in the viewing of pictures. In the second part of his Painting and society, Francastel (1951), described the “Destruction of a cubic space”. He too suggested that Cezanne played an important role in this process: Gauguin took it a crucial step further:

A new system of visualization elaborates itself. The qualities of space now concretize themselves. this time in a compartmentalization that no longer based on the differential scales of the veduta- combining the two well tempered grids of linear perspective and the single corridor of light- but on a new spatial ambiguity of support -the canvas- opposed to the autonomous values of pure colour. through
colour and through the theme, the decorative surface enlarges into three
dimension, and still more in the imaginary dimensions.313

The view that Cezanne heralded a rejection of linear perspective became very widespread
through authors such as Arnason, who wrote a standard History of modern art (1967 etc.)
which began from this premiss (9):

Perspective, although known in antiquity, became for the Renaissance a means of
creating paintings that were imitations of nature, visual illusions that made the
spectator think he was looking at a man, a still life or a landscape rather than at a
canvas covered with paint. Perhaps the greatest revolution of early modern art lay
in the abandonment of this attitude and the perspective technique that made it
possible. As a consequence, the painting - and the sculpture became a reality in
itself, not an imitation of anything else.

Arnason insisted that the visual evidence of the actual works was much more important
than verbal evidence even if this came from the artists themselves. Accordingly he
included 1549 illustrations in the revised edition (1983). If one looks at these closely one
is struck by the number of illustrations which continue to use perspective (cf. Sources,
pp. 194-201*) and one is led to ask oneself whether a cultural tradition which is basically
iconoclastic might not be affecting the historiography of modern art. Indeed is it a
coincidence that the protagonists of claims for a shift from perceptual to conceptual art
(e.g. Gablik, Blatt) are also members of the same tradition? Veltman (1993, 1994) has
offered further evidence of a revival of interest in perspective.

An exhibition at the Centraal Museum (Utrecht, 1978) on What is reality? raised some
questions concerning spatial illusions and perspective. Another exhibition at the same
museum by Blotkamp (1980) on Space and perspective (Ruimte en perspectief), which
grew out of a school project (1975), explored both modern and traditional examples in
terms of overlapping, light and shade, colour differences, mixing of colours, perspectival
diminution and viewpoints. Henderson (1983) in a stimulating thesis on the rise of the
fourth dimension in twentieth century art offered evidence that the situation might be
considerably more complex.

China, and the Far East

Practical interest in Chinese perspective began in the second half of the eighteenth
century in the context of landscape gardening and has been discussed elsewhere
(Sources, II.3). Interest in the history of perspective in the Far East has emerged only in
the twentieth century. Parmentier (1907) in a detailed study of the architectural bas-
reliefs of Java drew attention to their spatial features. Concern with Chinese methods
independent of the West has not yet received systematic study in the West. A major
exhibition organized by Ledderose and Butz in connection with the Berliner Festspiele
(1985) offers one of the few serious glimpses into the enormous riches to be studied in
this context. It is striking that the Chinese had a version of parallel perspective by the
sixteenth century (pl. 17.1), which was developed in the context of their chronicles
(pl.18-20).What set these apart from Western versions is that their narrative was not
compartmentalized into isolated episodes but integrated into a series of scrolls in a
continuous fashion (pl. 19) for which modern film techniques would be the only Western
“equivalent”, a problem upon which Hockney (19**) has reflected in a film on the subject.

The earliest use of Western perspective in China goes back to the Jesuits in the latter sixteenth century. Secondary literature on this topic began in the twentieth century. Laufer (1910), who was one of the first to explore this, made some mention of perspective. Pelliot (1921) pursued this theme in the context of engravings at the time of the Jesuit Father Ricci. Ferguson (1934) focussed specifically on painters among Catholic missionaries in Peking. Schüller (1936) cited other examples inspired by Father Ricci, a theme taken up by Hart Burling (1941). An important article by Loehr (1963) focussed on the role played by a seventeenth century Florentine Jesuit, Ferdinando Bonaventura Moggi, and demonstrated that western models affected architecture and landscape gardening as well as painting. The Jesuit theme was taken up anew by Palewski (1976). Liu Ruli (1979) wrote an article about the first Chinese editions of Pozzo (1729,1735), which were mentioned again in a discussion of Christian influences on Chinese art by Kao (1987).

March (1927) was one of the first who specifically included perspective in the title of an article on Chinese art. His extreme view that art had nothing to do with science was challenged almost immediately by Jacot (1927). Auboyer (1935) explored Chinese influence on oriental landscapes and sculpture, drawing attention to links between China and Java and noting some spatial features. Wells (1935) made an extensive study of proto-perspectival forms in art of the Han dynasty of the second century A.D. This theme was taken up anew by Fairbank (1942) in terms of Han mural art and pursued by Bulling (1962) in terms of a landscape of the western Han period.

In his monumental Science and Civilization in Ancient China, Needham (1971) drew attention to technical and scientific uses of perspective in the context of civil engineering and building. This theme was taken further in an important article by Edgerton (1980) which related divergent approaches to art in terms of different concepts of science in the west and east, a topic to which he returned in his book on Giotto (1990). This problem was touched upon also in the Berlin catalogue (1985) cited earlier, where it was demonstrated how some Christian motifs were mistranslated (pl. 21.1-21.2), in other cases traditional Chinese motifs were presented in Western fashion (pl. 21.3) while sometimes Western motifs were appropriated in an Eastern context, both as buildings and images (pl. 22).

Japan

During the Muromachi period in the sixteenth century Japan developed a version of parallel perspective which was applied to detailed townscape and landscapes (fig. 23-24). Aside from one standard study (19**) and a significant catalogue (1989), both in Japanese, the importance of this tradition has not yet been seriously studied by western scholars. Fundamental to the Japanese approach has been a particular attention to recording significant places, which had its roots in Chinese traditions. In the West, significant places on pilgrimages routes were marked with churches. Witness the growth of Romanesque architecture along the Vézelay- San Juan Compostella route linking France and Spain. In Japan, significant places were recorded in diaries and later became the subjects of woodcuts, of which Hiroshige’s series on the high road and coastal low
road linking Tokyo and Kyoto are perhaps the most famous. As Hoff (198*) has suggested the particular Japanese notion of (significant, often sacred) place helps to explain why they do not make the same oppositions between interior-exterior as are found in the West; why there is not the same subject-object tension and why there is not the same opposition between man-made and natural world in Japan. Hence while they have adopted Western techniques, they have applied them in very different ways.

According to Asano (1985), Western rules of painting were introduced by Christian missionaries in the sixteenth century but had effectively no immediate impact on Japanese artists because Christianity was outlawed. Chinese and Western pictorial art were re-introduced to Japan through Nagasaki after the eighth shogun, Yoshimune, lifted the import ban on books other than Chinese literature in 1720. It is generally accepted that Chinese woodblock prints which incorporated western perspective led to the development of uki-e in Japan. The word uki-e, which means “floating picture”, is etymologically connected with ukiyo-e, the so-called floating world, said to describe the court that travelled between residences in Edo (Tokyo) and Kyoto and which was defined as follows by Ryoi (1661):

Living only for the moment, turning our full attention to the pleasures of the moon, the snow, the cherry blossoms and the maple leaves; singing songs, drinking wine diverting ourselves in just floating, floating; caring not a whit for the pauperism staring us in the face, refusing to be disenheartened, like a guard floating with the river current: this is what we call the floating world.

Others have explained that the term derived from the fact that “the scene being represented in them seems to float outward, giving the work a three-dimensional quality” or “in acknowledgement of their illusory effect”315. Could it also be related to their typically being viewed through a zograscope (fig. 84.2)?

Masonobu Okumura (1686-1764), signed his work as “uki-e originator” and it said that the earliest known example of Western style perspective during this second period is his All star cast of a Kyogen stage (1740, pl. 25.1). He also represented the outside of a theatre (pl. 26.1) and The evening cool by Ryogoku bridge (late 1740’s)316. From a technical point of view the perspective in these works is not completely accurate. More interesting is the different approach to space which these works convey. The interior of the theatre does not show the audience separated from the stage, but rather a theatrical space in and through which players and audience interact directly. Similarly sharp distinctions between interior and exterior are handled differently than in the west. Interiors are often shown which interact with exteriors (e.g. pl. 26.2). Inner and outer, subject and object are not opposed: they complement one-another.

Masonobu’s print showing the interior of Nakamura-za in Kampo during the Kaomise performance (1740) was the basis of his student Torii Kiyotada’s print of a kabuki theatre performance of Mitsugi Taiheki at Nakamura-za in December 1743. The same artist did a Party at Yoshiwara (early 1760’s)317. Lee (1977) claimed that perspective was introduced to Japan via the Chinese translation of Pozzo (1737) and that it was Kiyotada who produced the first Japanese illustrations in perspective.

In the following generation, from the late Gembun to the Horeki period (1752-1764), uki-e became popular through other artists such as Moromasa Furuyama, Shigenaga
Nishimura, Kiyotada Torii, Kiyohisa Torii, Jogetsudo and Kogetsudo produced a striking perspectival print of a *Courtesan on a Veranda* (c. 1771).

Toyoharu Okumura (1735-1814) brought a further qualitative change in this technique (e.g. pl. 26.2). He is said to have copied a work of Visentini based on Canaletto (pl. 28). Nor was he alone in this (pl. 27). Hence the greater accuracy in perspectival construction partially reflects greater access to western exemplars. Toyoharu specialized in both “historical or group genre scenes and landscapes in perspective, often combining the two types”,

became an integrated form of Japanese art. By the age of the great landscapes of Hokusai and Hiroshige in the following century the perspective style had become so thoroughly assimilated that western students first seeing Japanese prints almost invariably chose these two masters as representatives of the pinnacle of Japanese art, little realizing that part of what they admire is the hidden kinship they feel with their own western tradition. (Ironically enough it was this work of Hokusai and Hiroshige that helped revitalize western painting toward the end of the nineteenth century, through the admiration of the Impressionists and Post-Impressionists.

Technically speaking, Hiroshige often deliberately gets the perspective wrong. For instance, in his view of *Suruga-cho* the “horizon line implied by the buildings on either side of the street is far below that implied by the mountain looming over them”.

Some perspective pictures, known as *Megane-e*, literally “eye glass pictures”, were used with both peep-shows (*nozoki karakari*, e.g. pl.83) and zograscopes (pl. 84). These pictures often included landscapes with distant vistas (pl.30).

Most of the secondary literature has been in terms of influences of western perspective on Japanese art. One of the standard works in Japanese (with a partial translation in English) is a catalogue from the National Museum of Modern art in Tokyo (1985). In English one of the earliest studies was Toyama’s (1936) *The Western-style colour prints in Japan*. French (1974) published a monograph on *Shiba Kokan-- Artist, Innovator and Pioneer in the Westernization of Japan* and three years later French (1977) produced an exhibition catalogue *Through closed doors: western influence on Japanese art 1639-1853*. Narazaki (1980) studied *Western influence and the revival of tradition in Ukiyoe-e*, a subject that was pursued by Sakamoto (1980) with respect to the Tokugawa period. A more general survey was provided by Sullivan (1989) in *The meeting of Eastern and Western art*. Screech (1991) in a penetrating dissertation on *The western scientific gaze and popular culture in late Edo Japan* made one of the most detailed English language studies of differences between Western and Eastern methods of representation. The
standard Japanese book on the subject remains by Yokoyama (1977) entitled: *Eye of Perspective. Space of Renaissance Italy and Japan*.

One of the few scholars concerned with the reciprocal influence of Japanese perspective on Western art has been Inaga (1978) who devoted a thesis in Japanese to this topic. Inaga (198*), summarized these findings in a significant article, in which he demonstrated how spatial themes in Hokusai are reflected in Cezanne (pl. 31.1-2 and 32.1-2). Bicknell (1994) drew attention to other parallels such as the bridges of Hiroshige and those of Whistler (pl. 31.3 and 32.3).

There has also been some work on cross-cultural spatial methods. A Russian article by Ikonnikov (1973) explored the spatial language of Japanese art. Etymologically the Japanese term for perspective is linked with the term for peep-hole, which was possibly as a result of having seen a Western style show-box. This might explain why some of the earliest Japanese prints using Western perspective are of theatre scenery. These problems are the subject of an article by Kishi (1990) *A view through a peep-hole: a semiotic consideration of Uki-e*.


A short chapter in Ganz (1994) on the social history of lanterns and show boxes (74-85) mentioned connections with the Far East, particularly Japan. One of the Japanese images (84) from a manuscript of the late eighteenth century, was based, as was kindly noted by my friend Corboz (personal communication), on Zocchi’s (1744) *View on the river Arno of a part of Florence taken outside the gate at the cross* (fig. 27). This is important because it confirms that Renaissance Italian perspective played a role in the development of the subject in Japan. Ganz’s extraordinary collection includes a Japanese manuscript of the 1760’s showing drawings of Dutch clothes and objects, e.g. a Leiden jar. Hence, Japanese fascination with Western technology began in the mid-eighteenth century, a century earlier than is generally assumed.

**Russia**

Russian historiography on perspective has emerged in the twentieth century. The mathematician Rynin, in his *Descriptive Geometry. Methods of Representation* (1916) considered the importance of both Ptolemy’s *Geography* and *Planisphere* for the history of perspective and listed a vast literature on links between the history of perspective and the evolution of descriptive geometry. Rynin’s work was one of the sources for a seminal article by Florenskij on *Inverted Perspective*, written in October 1919; read on 29 October 1920 at the Byzantine section of the Moscow Art-Historical and Museological Research Institute and published in 1922. A footnote to that article gave insight into Florenskij’s motivations. He recalled the vivacity of the discussions after his lecture which he claimed (73):
confirmed for me once more that the problem of space is one of the most fundamental in art, nay I would say in a concept of the world in general. But this problem: space in the figurative arts is not examined in the present article and constitutes the object of my readings on the analysis of perspective held in the years 1921-1923 which are being prepared for publication.327

Florenskij noted that he was interested mainly in outlining an historical approach for the comprehension of an organic world-view. He also cited Ernst Mach’s experience concerning the limitations of linear perspective and concluded (117): “Hence perspective in representation is not absolutely a property of objects as vulgar naturalism maintains, but simply a means of symbolic expression, one among the possible symbolic styles”.328 This was written five years before Panofsky gave his lectures on *Perspective as a Symbolic Form* (1924-1925, published 1927). Florenskij’s article offered a synoptic view of the history of spatial techniques from the Pompeian wall paintings in Antiquity to Giotto’s frescoes in the Mediaeval period to the works of Castagno, Leonardo and Raphael during the Renaissance. These he contrasted with methods of inverted perspective in Russian art to raise the question why artists should deliberately make paintings with deformed or even false perspective.

At the instigation of the graphic artist Favor斯基, Florenskij was given a chair for the analysis of space in works of art at the Moscow Higher Artistic-Technical Workshops from 1921 to 1924 where he developed his ideas on both Russian inverted and Renaissance linear perspective. A group emerged which included the mathematician N. N. Lusin and the artists M. F. Larionow, W. N. Tschekrygin and L. W. Shegin. Florenskij had raised the question whether the seeming naïveté of Russian could be taken at face value, noting that the rules of regular perspective were broken so often that it could hardly be coincidence. His colleague, Shegin made a lifelong study of these problems resulting in an article (1964) and a book (1970). Shegin argued that Russian icons were very systematic in their use of space; that they involved complex combinations of mirror images, cylindrical and spherical projections (pl. 15.3 -16).

Shegin did not discuss comparisons of painting and language although his book was entitled *Language of a Pictorial Work* (1970). These analogies were developed in an introductory essay by B. A. Uspensky who, having mentioned that some persons had assumed an ignorance of perspective among old Russian masters, observed that (7): an opposite approach is possible which could readily be compared with the method of decipherment. In this second approach the challenge arises of reconstructing the specific system of representation in old painting, i.e., to decipher the particular language, which the old master commanded and which was obviously understandable to an observer at the time. And from this system which needs to be deciphered one then must explain in detail all the deformations and shifts in form which have just been mentioned.329

Uspensky added that (12):

If one pursues the analogy with language then it is appropriate to compare the limitations of a given perspectival system with the conventional character of a given language which is used for the communication of a given content. Indeed it
gives grounds for the claim that the system of linear perspective cannot a priori be seen as more natural than other systems.\textsuperscript{330}

The title of Uspensky’s essay, “On the Study of the Language of Old Painting”, becomes all the more interesting when compared with the titles of a) Kepes’ \textit{Language of vision} (1944), b) Goodman’s \textit{Languages of Art} (1969), which has as a starting point the analogy of “learning to read pictures in reversed perspective” (see below p. 88\textsuperscript{*}), c) Mitchell’s \textit{Language of images} (1974) and it is realized d) that Uspensky, along with Florenskij and Bakhtin, played an important role in developing analogies between point of view in literature and art (see below pp. 112-113\textsuperscript{*}).

Nekrasov (1936) offered a brief survey of foreshortening in old Russian art from the fifth through the fifteenth century. Although he did not enter into the details of Shegin’s analysis, Rauschenbakh (1975) discussed the problem of inverted perspective at great length in the context of linear perspective and other drawing methods.

3. Histories of Mathematics, Astronomy and Science

In the sixteenth century encyclopedias such as those of Gregor Reisch (1509 etc.) and Fortius Ringelbergius (1531) surveyed mathematical practice but without historical consciousness. During the seventeenth century these encyclopaedic works gradually included historical references: e.g. Bettini (1642), Kircher (1646). Even so it was not until the second half of the eighteenth century that there was a sudden rise in formal historical treatments of mathematics. This began in Paris with a \textit{Universal dictionary of mathematics and physics} (1753) for which Saverien wrote an entry on perspective and the \textit{Encyclopaedia} of Diderot and D’Alembert (1765) for which the entry on perspective was written by Jaucourt.

Montucla’s (1758) \textit{History of mathematics from its origins to our days} and Saverien’s (1766; 1776-1778) \textit{History of progress of the human spirit} were among the first books specifically devoted to the history of mathematics. Modesty was not Savérien’s specialty as we learn from the opening sentence of his preface: “I do not believe that one could find in one book more truths than are found in this history\textsuperscript{331a}”. His treatment of the history of perspective was limited to four pages (253-256). With respect to Antiquity Vitruvius’ discussion of Democritus, Anaxagoras and Aristarchus was cited. The invention of renaissance perspective was attributed to Pietro del Borgo (Piero della Francesca) whose treatise, he claimed, was now lost but had been studied in the sixteenth century by Dürer, who “constructed a machine with which he found the trace of rays of light”,\textsuperscript{332} and Peruzzi who worked at rendering Piero’s ideas clear and precise. Savérien claimed that Peruzzi also found:

> the points of distance on which a line falls which makes an angle of 45 degrees with the painting such that their length on the horizontal line drawn on the panel is equal to the distance of the eye from the panel. Thereby he discovered that all horizontal lines making an angle of 45 degrees with the panel have as images lines that pass through the points of distance\textsuperscript{333}.

Savérien next considered Guido Ubaldi (Guidobaldo del Monte) who discovered “that all lines parallel to themselves and to the horizon even if they be inclined with respect to the axis of the panel, converge or tend to unite towards a point of the horizontal line and it is
by this point that the line drawn from the eye parallel to the others passes”. Savérien ended with a brief discussion of anamorphosis, citing the contributions of Stevin, Schott, Dubreuil and Leupold.

Copies of both Montucla and Savérien were owned by Lambert and it is noteworthy that he cited them explicitly as containing the first real attempts at a history of perspective, when he published his own historical introduction in the second part of his *Free perspective* (1774). In England, Priestley only referred in passing to historical aspects in his *Theory and practice of perspective* (1770) but pursued them in his *History and present state of discoveries relating to vision, light and colours* (1772). In Germany, Kästner’s (1797), *History of mathematics* offered a brief survey of perspective (1-8) and reviewed basic literature (9-34). Meanwhile the bibliographical work of Scheibel (1778) with 207 titles and Murhard (1797-1805) with 246 titles set a standard that was not surpassed until Vagnetti (1979).

In the first half of the nineteenth century, Piper wrote an article on perspective in the *General encyclopaedia of sciences and art* (Leipzig, 1834), but it was again in Paris that the key publications occurred. Chasles (1837) published a *Historical survey on the origin and development of methods in geometry*, with various comments on perspective such as Barbaro’s (1569) use of stellated polyhedra and a note (XVIII) “On the identity of homological figures with those which one finds in perspective practice. Remark on the perspective of Stevin.” Chales focussed attention on the importance of Desargues and Pascal and related their work on conic sections to their study of perspective. Chales noted that this mathematical work was taken up in the treatises of the artist, Abraham Bosse, and the engraver, Grégoire Huret, in the seventeenth century, later to be taken up anew by mathematicians (Servois, Brianchon, Poncelet, Sturm and Gergonne) in the context of homology. He also touched on the work of Guidobaldo del Monte, Mydorge and De la Hire in this context. Libri (1838-1841, 39-42) in his *History of mathematical sciences in Italy* mentioned the work of Danti (1583) and listed other authors: Alberti, Leonardo, Serlio, Barbaro, Vignola, Sirigatti and Guidobaldo del Monte. In an appendix (315-320) he published for the first time the opening section from Piero della Francesca’s *On perspective of painting*.

In the second half of the nineteenth century, Paris remained important chiefly through the monumental two volume *History of ancient and modern perspective* containing an exposition of all the known methods of perspective and an analysis of the works on this science by Poudra (finished 1854 published 1864, cf. review 1854). His study dealt with 132 texts. A first section focussed on the optical tradition, notably Euclid, Heliodorus of Larissa, Ptolemy, Witelo, Roger Bacon, Ramus and Risner, Reisch and Finé, Peckham, Aguilonius, Dechales and Lacaille. The second section began with remarks on drawing and painting among the ancients, and considered Vitruvius before turning to Piero della Francesca, Bramante, Baldassare [Peruzzi] of Siena, Leonardo da Vinci, Gauricus, Alberti, Pacioli, Pélerin, Dürer, Reisch etc. Most of the texts after 1600 were by French authors.

In retrospect there were clear limitations to Poudra’s work. His descriptions of contents were frequently cursory. Sometimes he was misleading. For instance he discussed the work of a J. Pisanus edited by Pachasius Hamellius (1556) and of a Joannis archiepiscopi
Cantauriensis (1592) without recognizing that these were merely two editions of the same work *Common optics (Perspectivae communis)* by John Peckham. On the other hand, it is important to note his genuine contributions. It had generally been assumed that Desargues was the first to recognize that a system of parallel lines in perspective becomes a bundle converging to a point. Poudra noted that this was first demonstrated by Guidobaldo del Monte (1600) and focussed attention on his list of 23 different methods of perspective. Poudra was, moreover, the first to emphasize the interdependence of optics and perspective historically and until Vagnetti (1979) remained the only attempt at a comprehensive survey of the field. Poudra (1861) also published a brief article on the fundamental theorem of Desargues. Marie (1884) referred briefly to perspective in his *History of mathematical and physical sciences*.

In Britain, De Morgan (1861-1863) wrote a series of nine witty anecdotal notes on the history of the perspective claiming that he had found nothing on the subject that deserved the name and beginning with Aeschylus as cited by Vitruvius, Hipparchus’ stereographic projection and Ptolemy’s planisphere projection. Notes two and three surveyed Renaissance authors. Note four focussed on Guidobaldo del Monte; note five on Desargues; six on Brook Taylor. Note seven reviewed Montaiglon’s edition of Pélerin; note eight added comments; note nine reflected on problems of distance and vanishing points. Cunningham (1868) produced *Notes on the history, method and technological importance of descriptive geometry* (cf. *Sources*, p. 134), which touched on the history of perspective. In Italy, Uglieni (i.e. Cremona, 1865, 1915) wrote on the principles of perspective according to Brook Taylor. Cremona (1865, 1921) also made a lengthy review of Poudra’s (1864) *History*. Significant bibliographical lists were provided in Riccardi’s (1870-1880) *Italian mathematical library* (cf. fig.3).

It was primarily in Germany, however, that a more critical approach to the history of mathematics emerged in the last three decades of the nineteenth century and first decades of the twentieth. Gerhardt (1877,25), in his *History of the sciences in Germany*, credited Dürer as being the first to introduce the principles of descriptive geometry. Dürer’s significance continued to receive special emphasis by mathematicians which helps explain the great rise of literature generally as well as a series of dissertations on Dürer (q.v. in Appendix 4). In his *History of mathematics*, Zeuthen (1877) included a section on “Geometry, Application of central projection”, noting the importance of Apollonius for Viète, Fermat, Pascal and ultimately De la Hire. The significance of Dürer, Werner, Kepler and Guidobaldo del Monte was acknowledged. Particular attention was focussed on the interdependence of Apollonius’ ideas and the contribution of Desargues. Zeuthen (1886) went on to write a history of conic sections.

Wiener’s (1884-1887) *Textbook of descriptive geometry* included a section on the history of descriptive geometry. As would be expected he mentioned the mathematical contributions of Hipparchus and Ptolemy, Guidobaldo del Monte and Desargues. Striking, however, was his acknowledgment of artists including Masaccio, Donatello and Ghiberti, as well as numerous authors of treatises written primarily for artists: e.g. Alberti, Piero della Francesca, Pélerin, Rodler, Lautensack, Cousin, indeed providing an important survey. The role of Dürer was emphasized. Desargues was given due credit. This survey extended through the eighteenth century with s’Gravesande (1707), Taylor (1715), Lacaille (1750), Lambert (1759, 1774), Zanotti (1766) and into the nineteenth
century. There were further sections on the evolution of ground-plan and elevation methods in relation to the development of descriptive geometry in France; relations between descriptive geometry and perspective in Germany; nineteenth century developments in oblique and axonometric perspective by Meyer and Meyer (1852), Pohlke (1860), Staudigl (1875) and even Hauck (1875) and Tessari (1882); relief perspective, photogrammetry, light and shade.

As part of Cantor’s (1894, 1908, 1913) Lectures on the history of mathematics, the Italian scholar, Loria, wrote a section on “Perspective and descriptive geometry” in four sections: from the middle ages to the seventeenth century (577-594); the so-called golden age of perspective theory (594-617); the precursors of Monge (618-622) and the role of Monge as the founder of descriptive geometry (623-637). Obenrauch (1897), in his History of descriptive and projective geometry (1897) also began with a short history of perspective that included Vitruvius, Peckham, Dürer, Leonardo da Vinci, Desargues, Lambert and Frézier. The main body of Obenrauch’s book focussed on developments in France (Monge) and in Austria. Obenrauch (1903), devoted an article to “The first space curve of the Pythagorean school and its orthogonal and imaginary projection”. Papperitz (1901) published On the scientific significance of descriptive geometry and its development until its systematic establishment by Monge, where he gave a summary treatment of the history of descriptive geometry, themes which he developed (1907-1910) in the section on descriptive geometry in the Encyclopaedia of the mathematical sciences. Here the contributions of Renaissance perspective were reduced to a single page (16), while other pages were devoted to Dürer (17), Desargues (18), and Stevin, Gravesande, Taylor and Lambert combined (19).

Burmester (1906) offered a brief history of perspective in relation to geometry in a festive address which traced its development from proto-perspectival efforts in Antiquity through the work of Brunelleschi, Alberti, Piero, Pêlerin, Guidobaldo del Monte, Desargues, to Breysig, Möbius, Steiner and Von Staudt. The eleventh edition of the Encyclopaedia Britannica (1911), in addition to a brief article on perspective, which focussed on its mathematical aspects, related it to developments in projective geometry and conic sections in an article on geometrical continuity. Appell (1912) claimed that Cousin’s Book of portraiture (1612) had been a precursor to Monge’s descriptive geometry. Ugleni (i.e. Cremona, 1915) examined Brook Taylor’s principles of perspective. Cassina (1921) examined perspective in relation to the development of the idea of points to infinity.

Fascination with the background to Monge culminated in Loria’s (1921, cf. above 1894), History of descriptive geometry, which remains a standard treatment of the subject over seventy years later, although it focussed very narrowly on strictly mathematical aspects and minimized the role of the artistic perspective. These themes were taken up again briefly in Günter and Wieleitner’s (1922-1923) History of mathematics and in an article by Amodeo (1932), who traced the contributions of Piero della Francesca, Dürer, Serlio, Commandino, Barbaro, Danti and his edition of Barozzi, il Vignola, Cousin and Guidobaldo del Monte. A second article by Amodeo (1933), examined the development of perspective in France, focussing on Vaulezard, Desargues and Aleaume, with mention of Aleaume, Bosse and Huret. General articles by Amodeo (1932, 1934, 1935) added little. Kaderavek (1935) considered perspective in the context of geometry and
architecture. Enriques (1938) briefly discussed key developments of perspective in a section on the origins of projective geometry.

Coolidge (1945), in his *History of conic sections and quadric surfaces*, returned to themes covered by Zeuthen. Enriques and De Santillana (1946) examined the role of perspective in their *Compendium of the history of thought*. Jones (1951), in a brief summary of an important unpublished thesis, examined the mathematical theory of linear perspective in Brook Taylor. Kline (1953) in a general book on *Mathematics in western culture* devoted a chapter on “Painting and perspective” and a further chapter on “A science born of art: projective geometry”. Wolff’s (1956) “History of perspective up to the year 1600” in five pages offered nothing new. Daumas (1957) in his five volume *History of science* touched on various aspects of the history of perspective. Taton, famous in the field for his important edition of Desargues (1951), wrote on various mathematical aspects of perspective: a general article on the background to modern geometry (1949); a *History of descriptive geometry* (1954); and in collaboration with Flocon, a *History of artistic perspective* (1963), which remains one of the best short histories of the subject.

Danielowski (1960) in a technical dissertation (Dresden), presented a succinct history of the subject beginning with a section on aspective (Agatharcus, Democritus, Democritus, Euclid, Hipparchus, Vitruvius, Ptolemy, Proclus) and pre-perspective (Alhazen, Bacon, Witelo, Peckham, Bradwardine) followed by an outline of fifteenth century (Brunelleschi, Alberti, Piero della Francesca, Leonardo) and sixteenth century (Dürer, Serlio, Barbaro, Vignola), seventeenth (Guidobaldo, De Caus, Desargues, Bosse, Niceron) and eighteenth century (Frézier, Lambert, Monge) figures.

Bense (1965) drew attention to mathematics in ornament. Havelka’s (1966) “Historical development of mathematical perspectival constructions” offered a technical outline of developments and also pertained to the related field of mathematical drawing instruments (see below p. 102ff.*). Morozzo della Rocca (1966-1967) examined mathematical harmony in architecture with particular reference to perspective. Vinaty (1985) examined the rise of projective geometry in the context of the figurative arts in the seventeenth century, focussing on the contributions of Kepler, and Desargues, with a section on anamorphosis which touched on Niceron, Kircher, Schott and Le Brun. This led to conclusions which related the work of Kepler, Galileo, Descartes and Kant.

Coxeter’s *Introduction to Geometry* (1961, 1969) as well as Coxeter and Greitzer’s *Geometry revisited* (1964) remain standard texts with numerous historical comments. May’s (196*) bibliography offered further titles as do lists in specialized fields such as Sperry’s (1931) *Bibliography of projective differential geometry*.

**Planispheres and Astrolabes**

In addition to these general works on the history of the mathematics there have been specialized studies on the history of planispheres, astrolabes and their projections. Serious interest in this field began with Delambre’s *History of ancient astronomy* (1817) and with editions of the treatises of Philonius by Hase (1839) and of Sabokht by Nau (1899). Favaro (1890) related an anonymous treatise on the astrolabe to Prosdocimo de’Beldomandi (now Florence, Biblioteca Laurenziana). Wittstein (1894) discussed the
construction of the astrolabe of Arzachel. Frank (1920) offered a brief history of the astrolabe basing his comments on Al-Biruni’s *Thorough treatise of all possible methods for the composition of the astrolabe* and Frank (1922) went on to publish a detailed account of Al-Chwarizmi’s use of the astrolabe. As part of the same series Nolte (1922) outlined the history of the armillary sphere.

Drecker (1927), basing himself on Heiberg’s collation of six extant manuscripts, published a first German translation of Ptolemy’s *Planisphere*. A first attempt to catalogue all extant astrolabes along with versions of the major texts was made in a fundamental work by Gunther (1936) which contains an important bibliography. Michel’s *Treatise on the astrolabe* (1947), remains the most lucid study of basic principles and history. Neugebauer (1949), reviewed the early history of the astrolabe.

**Map Projections**

Technical discussions of the history of map projections comprise another area of study that relates to the history of perspective. In terms of ancient cartography, Reinganum (1839) provided one of the first serious surveys. Honigmann’s (1929) book on the *Seven climates* provided important source materials concerning links between astrology and history in the Middle Ages. In terms of Ptolemy’s methods the fundamental studies remain those by Mollweide (1805, 1817), Arnold (1909), who focussed on Ptolemy’s use of a grid system, Schnabel (1930) and von Mzik (1933, 1938). In English the standard articles remain Cooley (1854), Tudeer (1917) and Bagrow (1945), who reviewed theories concerning the origins of Ptolemy’s *Geography*. Cebrian (19**), who attributed to Thales the use of central perspective, claimed that in addition to his two basic projections Ptolemy had developed a third improved conic projection. Neugebauer (1959) translated the passages from Ptolemy’s *Geography*, Book VII, chapters 6 and 7, offering a careful commentary noting, for instance that (28): “The meridians are drawn -probably as circle arcs- through three points which are determined on the northern and southern limit of the oikoumene and on the parallel PSX. Thus the representation is again a mapping preserving distances on three parallels and not a perspective picture”. Notwithstanding this clear statement scholars such as Edgerton (e.g. 1975, 1991) have cited Neugebauer as evidence that Ptolemy had a third method of cartographic projection which employed linear perspective.

In terms of Renaissance cartography, Toscanelli is a key figure because of his friendship with Brunelleschi. Fundamental in this context remains the monumental work of Uzielli (1894), who also wrote an article (1902) on the relationship of Paolo Toscanelli and Antonio di Tuccio Manetti. Uzielli was considered critically by Wagner (1894) who offered his own reconstruction of the Toscanelli map. A new awareness of the wealth of cartographical sources was provided by a series of studies on materials in German libraries (1904-1916). Lemoine studied links between astronomy, surveying and painting in an article “On the oblique horizon and the use of the torquetum by painters” (1960-1961). Links between surveying, cartography and painting were explored by De Smet (1966).

With respect to general histories of cartographical projection, D’Avezac’s (1862), monograph cited in our first volume *Sources*, pp. 28-29*) remains of fundamental importance. Keuning (1955) published an important article on “The history of
geographical projections until 1600” which remains the best brief introduction to the problem. Merriman (1947) offers a useful *Introduction to map projections*. Basic in the field of nomenclature and classification of map projections remains Lee (1944). Also important in this context is Chovitz’ (1952) “Classification of map projections in terms of the metric tensor to the second order”. On the question of Russian map projections, Maling (1960) remains basic.

4. Treatises

As historical records of practice and theory the treatises go through three distinct phases. In the first century (1430-1530) they contain hardly any historical notes. Filarete’s *Treatise on Architecture* (c.1464), which refers to Brunelleschi’s demonstration and to Alberti’s treatise, is an exception. The other early treatises of perspective: i.e. Alberti’s *On Painting* (1435); Francesco di Giorgio Martini’s *Treatise on Architecture, Engineering and Military Art*; Piero della Francesca’s treatises (*On the Abacus, On the Perspective of Painting* and *On the Five Regular Solids*); Leonardo da Vinci’s *Manuscript A*, make no reference to practical spatial achievements of Renaissance artists. Moreover, the titles of these earliest treatises remind us that perspective began in the shadow of other disciplines. Etymologically and historically it was closely linked with optics. Alberti associated it with painting; Filarete linked it with architecture; Francesco di Giorgio Martini with geometry and surveying. Vasari’s *Lives of the Artists* (1550) associated perspective with a whole range of disciplines including painting, architecture, inlaid woodwork, and goldsmithing.

In a second phase (1540-1758), the treatises frequently contain brief paragraphs on the history of the subject, which provide useful insights into who was considered important at the time. Pélerin (1505) prepared the way for this approach with a list of surnames. Serlio (1540 etc.) went further: he cited the work of Dürer and mentioned some of his contemporaries. Having made the point that architecture, painting and perspective are closely interrelated, Serlio asked in his preem:

> For, was not Bramante an excellent Architect, and was he not first a painter who had great skill in perspective art, before he applied himself to the art of architecture? And Raphael D’Urbino, was not he a most cunning painter and an excellent perspective artist before he became an architect? And Baldassare Peruzzi of Siena, was also a painter, and so well seen in perspective art that he, seeking to place certain pillars and other antique works perspective, took such a pleasure in the proportions and measures thereof, that he also became an architect, wherein he so excelled, that his like was almost not to be found. Was not the learned Geronimo Genga also an excellent painter and most cunning in perspective art as the fair works which he made for the pleasure of his Lord Francesco Maria, Duke of Urbino, can testify, under whom he became a most excellent architect? Giulio Romano, a student of Raphael D’Urbino who by perspective art and painting, became an excellent architect witnesses the same.334

It is noteworthy that Serlio cited only contemporaries and made no reference either to fifteenth century practitioners or authors. By contrast Barbaro (1568), who wrote the next Italian treatise, included a sketchy history of perspective theory:
But in what way and with what precepts they were arranged, no-one (as far as I know) has left any memory in their writings. Unless we wish to call precepts and rules some light practices established without order and foundation and explained roughly, since of these there are some by Pietro dal Borgo S. Stefano [i.e. Piero della Francesca?] and by others which will serve for idiots. Dürer left few things, although they were ingenious and subtle. Serlio dealt with the matter in a rougher way. But both of these authors (I would say) stopped too soon. The painters of our time, otherwise famous and with a great name, let themselves be guided by a simple practice....Federico Commandino in the Planisphere of Ptolemy has made some learned demonstrations as is his wont, pertinent to perspective as principles of this, not useless to excite the minds of the studious; but useless as far as practice is concerned and introducing new persons to work in obscure and difficult ways.335

Egnazio Danti in his commentary on Giacomo Barozzi (il Vignola’s) Two Rules of Practical Perspective (1583) marked a major step forward in historical consciousness, but he too made no mention of fifteenth century authors other than Piero della Francesca. Danti noted that Piero wrote three books relating to perspective; that Piero was an important source for Barbaro, as was Baldassare Peruzzi for Serlio. He cited the French authors Jacques Androuet Du Cerceau and Jean Cousin and his Italian contemporary, Pietro Cataneo. With respect to the ordinary rules he referred to books by Leon Battista Alberti, Leonardo da Vinci, Albrecht Dürer, Fortius Ringelbergius, Lencker, Viator and Commandino. On the topic of regular solids Danti cited the works of Jamnitzer, Piero della Francesca and Luca Pacioli. In the course of his commentary Danti referred to various other practitioners and theorists, including Tommaso Laureti, Baldassare Lanci and even Simon Stevin (over 20 years before this author published on perspective). Danti did not however provide either titles or dates of publication for the texts. Nor did he attempt to trace the history of perspectival practice.

Pfintzing (1598) marked a first serious attempt to chronicle developments in perspective in Nürnberg from the time of Dürer to the 1590’s, citing both published and unpublished contributions. Pfintzing was exceptional in including dates and titles and in giving a detailed description of each work. The tendency was towards lists usually without titles and dates. These lists became a regular feature in the introductions of perspective treatises, but they were seldom accurate. For instance, the Jesuit Father Dubreuil, author of the famous, anonymous Practical Perspective (1642-1649), which went through over 30 editions, claimed that Gregor Reich was the earliest treatise on perspective that he had encountered, followed by the text of Viator. (In fact editions of Gregor Reisch contained a pirate edition of Viator). The German edition of Dubreuil (1710) went on to mention Dürer, Jean Cousin, followed by: “Daniel Barbaro, Vignola, Serlio, du Cerceau [i.e.Androuet du Cerceau], Sirigaty [Siriagatti], Salomon de Caus, Mar[o]lois, Vredement, Vriese [Vredeman De Vries], Guidus, Ubaldus [Guidobaldo del Monte], Pietra Acolty [Accolti], Sieur De Vaulezard and M. Desargues”.

In a third phase, the perspective treatises typically contain a specific chapter on the history of the subject. Lambert (1759) was probably the first to do so seriously. He cited Montucla’s claim that Pietro del Borgo San Stephano [i.e. Piero della Francesca of Borgo San Sepolcro?] was the first to use perspective, followed by Baldassare Peruzzi, who was
credited with the invention of the distance point. Lambert’s list of early authors included Leonardo da Vinci, the work edited by Rodler (1530, 1546), Daniele Barbaro (1569), Lencker (1571), Egnazio Danti and Guidobaldo del Monte (1600). Once again fifteenth century theorists as well as the early practitioners were largely ignored.

This approach continued into the twentieth century. Cole (1921) listed Bartolomeo Bramiantino (1464), Pacioli (1494), Dürer (1525), Cousin (1560), and Guidobaldo del Monte (1600). One of the standard books of the past generation, Abbott (1950) has an historical survey which mentions Uccello, Masaccio and the Van Eycks in terms of practice. Alberti (which he claimed was published in 1434, the year it was written, rather than 1540, the year of the first edition), Jean Pélerin (1505) and Dürer (1525), Vignola (1583) and Guidobaldo del Monte (1600). Hence treatises even in the modern period have remained remarkably primitive in their mention of historical practice and theory.

5. Encyclopaedias

Voleterrannus (1506), appears to have been the first encyclopaedia to deal with perspective as a secondary source, mentioning in passing only a few authors (see p. 43*). Most of the encyclopaedia in the sixteenth, seventeenth and even eighteenth centuries contained random notes in the form of secondary literature and focussed on re-printing either full texts or handy summaries. For instance, Gregor Reisch’s *Philosophical pearl (Margarita philosophica, 1509)* included Pélerin’s *On artificial perspective*. Rivius (1547) included texts by Alberti, Serlio and Gauricus. In the third decade of the seventeenth century the Jesuits introduced a new type of mathematical encyclopaedia. This began with the brief descriptions of problems in optics, perspective etc.: Ens (1636). In the next decades the scope of these expanded enormously through the works of Bettini (1642), Kircher (1646), Schott (166*), Millliet de Chales (167*). Meanwhile many treatments remained summary at best such as the entry under perspective in Baldinucci’s (**), *Tuscan vocabulary of the art of drawing*, which mentioned in passing the works of Barbaro, Accolti, Leonardo, and Danti’s commentary on Vignola. Similarly, the author of the *General theory of fine arts* (1779) focussed attention on technical principles leaving only one column at the end to mention his conviction that although the ancients had some knowledge of a science of perspective it remained in a primitive state. He mentioned in passing the work of Leonardo and Dürer and referred those readers interested in the history of the subject to the introduction of part two of Lambert’s *Free perspective*.

Interest in historical aspects of perspective grew through mathematical encyclopaedias in the 1850’s and 1870’s (cf. above p. 57*). Some nineteenth century authors such as Piper, in Ersch and Gruber’s (1843), *Encyclopaedie der Wissenschaften und Künste* continued to focus on technical aspects of perspective, relegating historical considerations to a page and a half of significant titles from the time of Gauricus (1504) to nineteenth century examples such as Eytelwein (1806) and Schmid (1826). By contrast, Bosc (1879) in his *Dictionnaire raisonné de l’architecture*, began with a short definition (twelve lines) followed by nearly five columns on the history of perspective. Bosc cited passages from Vitruvius and Pliny to counter the claims of those who denied the existence of perspective in Antiquity. Three further columns dealt with basic concepts of perspectival practice, and were followed by a bibliography of sources (one and a third columns). Julien (1885) in his article on perspective in Planat’s *Encycopedia of architecture and
construction focussed mainly on technical aspects, relegating historical comments to a note with references to Leonardo, Burnet, Vallée, Chevreul, Bruecke and Helmholtz. The author, O. H. (1911), in the eleventh edition of the Encyclopaedia Britannica, also focussed on technical aspects of perspective, referring only to Stanley’s Descriptive treatise on mathematical drawing instruments.

The anonymous author of the article on perspective in the Enciclopedia universal illustrada (1921) began with a detailed technical description (eight columns), followed by a section on perspectival instruments which entailed several references not usually found in the literature: e.g. diagrafo of Charles Gavard; paralelo universal of Verzy (1810) the quarregrafo of Ancracher (1820), the secater perspective of Lalanne and the stereografo of Fevret de Saint-Misme. A long bibliography (nearly six columns) was notable for its emphasis on eighteenth and nineteenth century authors on perspective, many of them seldom cited before. A section on perspective in painting relied heavily on Nielsen and referred to the work of Leonardo.

The Encyclopaedia of world art contains an extensive, important article on perspective by Gioseffi (Italian 1958, English 1965), which is misleading in that it presents the author’s personal interpretation of the history of the subject, essentially unchanged from that in his main book (1957), without indicating the existence of alternative views. For instance he claims that there was clear knowledge of linear perspective in Antiquity and that Giotto re-introduced the principles of one-point perspective at the turn of the fourteenth century. This bias is reflected also in the seemingly rich bibliography, which omits reference to the most important literature contrary to his viewpoint. A second entry by Gioseffi in the same work, on optical concepts contains useful references to debates concerning links between curvilinear theories of vision and representation with some reference to camera obscuras and anamorphosis, but once again his presentation is one-sided with little indication either of the historical richness or complexity of the debates (cf. below pp. 78 ff.). By contrast, an excellent third article in this work by De’Maffei (Italian 1958, English 1965) on perspectivists, which focussed on illusionist ceiling painting (quadratura), offered the most thorough English language outline of this subject, although the author did not cite Kellermann’s fundamental contribution.

A section on space and time in the Enciclopedia universale dell’arte began with headings Francastel (1964) on temporal expedients in traditional figurative arts, the time of vision in an image; time and memory; time and space and a “Brief history of figurative systems in space-time”, which drew heavily on his earlier books (cf. above p.56*). A further heading by Battisti (1964), addressed the “Possibility of relations in space-time” and considered the contributions of individuals ranging from Giovanni Fontana, Piero della Francesca and Giulio Romano to Paul Klee and Marcel Duchamp.

An entry on perspective by Carter (1970) in the Encyclopaedia of world art is the best concise introduction to basic principles and the history of the subject. Carter noted the scientific basis of perspective, the psycho-physical basis of the perspective illusion, cues for the perception of depth, basic definitions, measuring in perspective, and marginal distortions. Carter gave a lucid summary of the theory of vanishing points and Desargues’ theorem; the distance-point or three-point construction before offering an outline history of perspective: Antiquity, the role of Euclid, Byzantine, Post-clasiscal,
Mediaeval periods, the Renaissance and modern times. Carter, one of the greatest modern practitioners is exemplary in his precision.

Volume eleven of *Artistic techniques* contained an appendix by Franchini Guelphi (1973) on “The organization of the image in plane figuration: perspective techniques”. Guelphi claimed that perspective was neither an objective instrument of reality nor a system of immutable laws rigourously based on the natural laws of vision.” Under the heading of optics and scenography in Antiquity, Guelphi rejected Panofsky’s interpretation as “approximate and arbitrary” and instead accepted Gioselli’s (1957) claim that the Vitruvian passage indicated the use of linear perspective in Antiquity. The views of White were also reported. With respect to the Middle Ages, Guelphi mistakenly claimed that Alhazen was the first author to describe the camera obscura (cf. below p.103*), and reviewed the empirical contributions of Giotto, Lorenzetti, Jean de Pucelle’s *Belleville Breviary* (*Bréviaire de Belleville*, before 1343) and the *Hours* (*Heures*, c. 1395) of the Duc de Berry.

With respect to the Renaissance Guelphi cited Argan’s (1955) views of Brunelleschi as “the first to think of architecture as space”; cited Parronchi’s analysis; and Edgerton’s interpretation of Alberti; outlined the contributions of Piero della Francesca, mentioned a lost treatise by Poppa; and the treatises by Filarete and Gauricus. There followed sections on empirical methods and the systematization of Nordic artists, notably, Pélerin; the crisis of linear perspective in the late fifteenth and sixteenth centuries, i.e. the use of curvilinear methods and anamorphosis; scientific systematization in the seventeenth century; the rise of quadratura; Canaletto and the illumined view of the eighteenth century and the role of photography. A brief entry on perspective by Dalai-Emiliani (1985) in the *Encyclopaedia universalis* provided a concise summary of the field and added some new material in a section on twentieth century debates.

In retrospect it can be seen that there has been a gradual shift in the encyclopaedic literature from primary to secondary literature, from technical accounts of perspectival principles to summary accounts of its history and notwithstanding notable exceptions such as Carter (1970) there has been a tendency for these accounts to be secondary in another sense. The most penetrating historical studies remain in the form of specialized monographs and articles.

6. Bibliographies

Thus far there have been at least thirty six bibliographies with sections devoted specifically to perspective. These are listed below (fig. 13) chronologically by author with the number of titles on perspective cited by each. Vasari is not included because, although he refers to writings, he does not refer to specific titles or editions.

<table>
<thead>
<tr>
<th>Year</th>
<th>Author</th>
<th>Titles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1590</td>
<td>Lomazzo</td>
<td>7</td>
</tr>
<tr>
<td>1605</td>
<td>Hulsius</td>
<td>14</td>
</tr>
<tr>
<td>1610</td>
<td>Draudius</td>
<td>18</td>
</tr>
<tr>
<td>1651</td>
<td>Leonardo</td>
<td>7</td>
</tr>
<tr>
<td>1682</td>
<td>Lipenius</td>
<td>38</td>
</tr>
<tr>
<td>1704</td>
<td>Pellegrino</td>
<td>32</td>
</tr>
<tr>
<td>1706</td>
<td>Sturm</td>
<td>8</td>
</tr>
<tr>
<td>1711</td>
<td>Fullenius</td>
<td>31</td>
</tr>
<tr>
<td>1821</td>
<td>Cicognara</td>
<td>156</td>
</tr>
<tr>
<td>1830</td>
<td>Rogg</td>
<td>57</td>
</tr>
<tr>
<td>1836</td>
<td>Fielding</td>
<td>9</td>
</tr>
<tr>
<td>1861</td>
<td>Beelitz</td>
<td>27</td>
</tr>
<tr>
<td>1864</td>
<td>Poudra</td>
<td>132</td>
</tr>
<tr>
<td>1873</td>
<td>Löffelholz</td>
<td>138</td>
</tr>
<tr>
<td>1876</td>
<td>Anonymous</td>
<td>102</td>
</tr>
<tr>
<td>1888</td>
<td>Sodeñ-Smith</td>
<td>320</td>
</tr>
</tbody>
</table>
Fig. 13. Dates, authors of bibliographies and number of books listed.

Strictly speaking Lomazzo’s *Idea of the Temple of Painting* (1590) is also not a bibliography. It is included here because it contains some of the earliest clear references to perspective treatises. It made little mention of fifteenth century sources other than Leonardo, and while mentioning sixteenth century authors such as Peruzzi and Serlio, focussed attention on the Milanese school: Foppa, Butinone and Zenale. Hulsius (1605) listed fourteen works in the midst of treatises on geometry and surveying. Hulsius (1604) was also important for being one of the first to publish on the proportional compass, a universal measuring instrument which included perspective in its scope. Draud(ius) (1610) listed only four authors under the heading of perspective: Crameri [Krammer] (1600); Lautensack (1564), Lencker, and Vredeman de Vries, although further authors were included under other headings such as architects and geometers (Androuet Du Cerceau 1576, Vredeman de Vries 1612); architecture (Vredeman de Vries 1609, Krammer 1600, Ryff 1582, Serlio 1608); fortifications (Faulhaber 1610, Perret 1602, Specklin 1599); the art of writing (Lencker 1595) and geometric instruments (Hulsius 1592, 1594).

Subsequent bibliographies gradually included more of these titles under the heading of perspective. The 1651 edition of Leonardo still included seven books on perspective in a list of books on art. Lipenius (1682), by contrast, marked a first significant number of books (38) specifically listed under the title of perspective. This had the expected German works (Durer, Lautensack, Lencker, Pfintzing, Faulhaber), but was noteworthy for adding an international selection including Italian authors (Barbaro, Barozzi il Vignola, Guidobaldo del Monte, Accolti), French (Aleaume, Desargues, Bourdin, Dubreuil), Dutch (Vredeman De Vries, Hondius, Marolois), and even English authors (Moxon, Prick as translator and editor of Dubreuil). Pellegrino’s (1704) list of books on architecture and perspective explicitly cited the year of publication and the city where the work was published. He linked architecture and perspective and focussed on Italian works although French works by Desargues, Felibien, Josse, De Lorme, and Niceron and the German work of Jamnitzer were cited.

Doppelmayr (1730), in a fundamental study of the Nürnberg mathematicians, was among the first to develop a careful biographical approach with detailed bibliographical information, prefiguring the modern bio-bibliographical approach. In so doing, Doppelmayr provided important insights into the social and intellectual context of perspectival activities. He drew attention, for example, to a debate concerning the structure of the cosmos arising out of the Aristotelian tradition via Averroes, which was
one of the incentives for Regiomontanus to write his treatise on the regular solids. Doppelmayr was remarkable for his detailed references which cited his sources.

Murr (1770) produced a quantum leap forwards with a list more than three times the length (101 titles) of Lipenius mainly with examples from art history. Murr marked a watershed in other respects also. His titles were more accurate and when in doubt he gave the source of his reference. That same decade Scheibel (1778) more than doubled the known number of texts (from 101 to 207).

The last decade of the eighteenth century brought two more pioneering works. Comolli (78) treated a relatively small number of texts but discussed their history with a new level of critical acumen carefully weighing conflicting evidence from different sources. In the case of Leonardo, for example, he provided a context for historical study of the manuscripts. Murhard (1797-1805) produced what was to remain the largest bibliography on perspective (246) until the late nineteenth century as part of a massive five volume bibliography on all aspects of the history of mathematics. What made Murhard’s work a remarkable contribution is that he painstakingly recorded every book he had actually had in his hands and carefully documented his references in the case of books he had not seen at first hand. This introduced standards of accuracy to his bibliography which have not been uniformly evident even in subsequent contributions.

The early nineteenth century brought one serious bibliography (with 156 titles on perspective) based on the private collection of Count Cicognara (1821), now in the Vatican Library. In the second half of the century, Poudra (1864) made the first attempt to write a history of perspective from a mathematical viewpoint (see above), using a list of (132) titles as a point of departure. The rise of the National Art Library at South Kensington led Soden Smith (1888) to produce the largest bibliography (320) prior to Vagnetti (1283). This and the catalogue at Neuwied (1876, cf. Sources, fig.46-47), placed perspective in a larger context of drawing books. Meanwhile authors such as Rogg (1830) and Beelitz (1861) were drawing attention to further connections between perspective and mathematics particularly in the realm of conic sections. Riccardi (1889, 1893) furthered this trend by consciously searching for titles not listed by Poudra and by making perspective but one part of a larger bibliography including various branches of the mathematical sciences.

In the twentieth century, Loria (1921), continued this mathematical theme in the context of descriptive geometry. There were three further catalogues of important collections, Amsterdam (1934), Berlin (1939) and the Fowler Architectural Collection (1961), the last of which introduced a new standard in bibliographical detail and accuracy. Schüling (1973), the chief librarian at Giessen, also produced a model bibliography which attempted, for the first time, to give some idea of extant copies of perspective treatises written before 1601. Vagnetti (1979) in a pioneering work combined for the first time titles from the realm of optics, art, architecture and mathematics to arrive at a list four times longer than any earlier bibliography (1283). Vagnetti patiently collected titles for over thirty years and provided useful descriptions both for major periods and individual authors.

Vagnetti was convinced that there was much more to be found and it was specifically at his suggestion that the present author undertook to write some 65 libraries. This number
has since expanded to over 180 (see Sources, V.2) and has brought to light over 8,000 titles of primary and 7000 titles of secondary literature. Ironically, five hundred years after the introduction of perspective we are only beginning to become aware of the enormous corpus of material that awaits study.

7. Conclusions

Our survey of the historiography of perspective has focussed on work by historians of art, and mathematics as well as authors of treatises, encyclopaedias and bibliographies. Historians of art have tended to focus on a given period, treatments of which have varied considerably. In the case of pre-history it is notable that there was little serious study prior to the work of Lange (1899), followed by the fundamental work of Schäfer (1919) since which time there has only been a new edition of Schäfer (1974) and one major contribution by Groenewegen-Frankfort (1951).

With respect to perspective in Antiquity the debate is much older with one side claiming that they did have perspective: e.g. Vitruvius (1521) and Philostratus (1578); while another side has argued that they did not or even could not have had perspective: e.g. Rubens (1636) and Perrault (1692). While these debates have continued for the past three centuries, it is striking to note how the evidence cited in these debates has shifted enormously. In the sixteenth century the presence of a related word such as proportion or analogy in an Ancient text was frequently considered sufficient as evidence. In the seventeenth century the concept of evidence expanded to include relevant passages from Ancient sources and general allusions to examples. In the eighteenth century European scholars, particularly in Paris and London, sometimes relied on second hand reports of those who had travelled to Rome, Pompeii and Herculaneum.

For examples of perspective they also turned to a wider range of objects, including ancient coins and cut stones as well as paintings. In the nineteenth century this list expanded further to include architecture, largely through the rise of archaeology which saw a new interest in actually measuring the ruins and studying details of their entasis and other possible optical adjustments. With respect to sources there was new interest in citing sources in the original Greek and Latin, collecting these systematically and analysing them with the new tools of the emerging discipline of philology. The last quarter of the nineteenth century added the visual evidence of drawings and photography to the repertoire, a trend which has continued through the twentieth century although there is still no readily available corpus with colour photographs of all the visual materials. As Bergmann (1994), has noted, digital reconstruction and computer generated reconstructions linked with virtual reality are emerging as new tools in the case of sites such as Pompeii. Similarly, although there have been some attempts to analyze (pseudo-) perspectival lines, a systematic study of their possible underlying lines has yet to be made. Perhaps the only area where there has been some approximation of systematic treatment is in the context of textual sources, where scholars have paid increasing attention to comparing and integrating evidence from literary (Plato, Vitruvius) and mathematical sources (Euclid, Hero of Alexandria, Ptolemy, Proclus).

Historiography of the Mediaeval period (321-1300) has generated three basic interpretations. A first, introduced by Vasari, ignored the early Middle Ages and saw Cimabue and Giotto in the late thirteenth century as the pioneers of new methods that led
directly to the Renaissance. A second view has focused on the same timeframe but has suggested that this birth was in fact a rebirth of methods which had been introduced in Antiquity. The most famous exponents of this approach have been White (1957) and Parronchi (1957, 1958, 1964), the latter of whom has expanded the context of discussion to include mediaeval optics (Witelo) and literature (Dante). A third interpretation has argued for a continuity throughout the Middle Ages of certain spatial motifs that were initiated in Antiquity. This view, established by Kallab (1900), Kern (1912) and Goldschmidt (1916), found its most famous exponents in Panofsky (1927) and his follower Bunim (1940).

With respect to the Renaissance, from the time of Alberti’s *On Painting* (1434), the first treatise on perspective, there have been debates about whether it was something entirely new or merely a re-birth of Ancient methods. All have agreed that something important happened. Thoughts about wherein that contribution lay, who the key figures were and the scope of their activities have, however, changed greatly in the past centuries. The fifteenth century offered only isolated comments about the rise of perspectival methods. The sixteenth century, most notably in Vasari, saw first attempts at documenting the phenomenon, with a marked emphasis on the role of Florence and both a conscious and unconscious downplaying of the importance of other centres. The seventeenth and eighteenth centuries added mainly general comments and shifted attention to perspective in the sixteenth century. The latter nineteenth century saw a first attempt to reproduce basic sources (Alberti, Filarete etc.) a process that has continued into the twentieth century. This also led to analysis of the actual methods used and first attempts to determine how these methods worked in the actual paintings by reconstructing their vanishing points, an approach that has continued to gain ground. In the last decade of the nineteenth century, Nielsen introduced the idea of studying specific centres, notably, Florence, Umbria, Rome, Siena, Milan, Urbino, Padua and Venice. The twentieth century has developed aspects of this approach through champions such as Chastel who have taught us to look at Italy as a whole series of centres. A number of scholars, most notably, Parronchi and Edgerton, have continued to emphasize the central importance of Florence. Some, particularly Battisti and Dalai Emiliani, have drawn attention to the importance of Milan and Northern Italy as a whole in the early history of perspective. White and Gallet have focussed new attention on the particular role of Padua.

In all there have been hundreds of articles on Renaissance perspective. If we stand back, however, to look at the big picture, it is striking to note what has not yet been done. Linear perspective evolved in two contexts: one narrative, as in the lives of the saints mainly in fresco; the other, emblematic, mainly in inlaid wood (intarsia), dominated by scenes of idealized towns, and instruments. In the case of narrative, notwithstanding a monumental contribution by Kaftal, which is being continued by the important work of Bisogni, we still do not even have a catalogue of all the narratives involved. In the case of emblems, there have only been discussions and plans for a comprehensive catalogue. In short no one has access to the primary materials either in terms of practice or theory. While all the major texts of the fifteenth century are now available in some form, no compendium of extant manuscripts of the early period has even been attempted.

Meanwhile our knowledge of individual centres is far from complete. While the importance of Florence continues to be emphasized, it is often forgotten that the most
striking examples of proto-perspective are South of Florence along an axis which starts
from Assisi and runs northwest via Perugia and Cortona to Arezzo and then west to
Siena; with another axis that runs almost directly North from Assisi through Gubbio,
Citta di Castello (cf. Raphael) to Sansepolcro (cf. Piero della Francesca) whence it
branches both west to Anghiari and Arezzo and east to Urbino. It is generally known, that
the connections between these centres were largely through the travels of artists such as a
Giotto who worked in Assisi, Padua and Florence; or a Masolino who worked in
Florence, then San Clemente in Rome, before going to Castiglione D’Olona on his way
to Budapest. With computers it is possible to make dynamic maps which trace these
peregrinations systematically and allow us at the same time to trace the spread of specific
themes. Approached in this way, studies of Renaissance perspective have scarcely begun
in spite of claims by some that the field has been exhausted.

In the case of perspective since the Renaissance, the immensity of what has not yet been
studied is even more striking. While there have been significant studies on individual
applications such as ceiling painting or theatre, as well as of individual artists, the
interplay between techniques and the details of influence have remained largely
unexamined. Pioneering work on the institutionalization of artistic techniques, largely
through the academies, (e.g. Pevsner) have provided an initial framework for
understanding how teaching shifted gradually from the context of masters in workshops
to courses in schools How perspective was in the process reduced to a dry, academic
subject, devoid of creativity has yet to be studied. So too has the whole resurgence of
perspective in the second half of the twentieth century.

In the history of mathematics, it was only in the second half of the eighteenth century that
a serious interest in the history of perspective emerged in Paris. This remained the chief
centre for over a century until the 1870’s when Berlin and Leipzig became the leading
centres in Germany. For a period of nearly fifty years there was a concerted effort to
understand major patterns in the history of mathematics, culminating in the studies of
Cantor. One of the major motivations for studying perspective was a belief that Dürer had
been the founder of descriptive geometry. When a series of dissertations demonstrated
that this was not the case, German interest ebbed. While the period since the early 1920’s
has produced a series of isolated studies, attempts to understand the big picture have been
absent, mainly because of trends in specialization.

The earliest treatises (1435-c.1539) contained hardly any historical notes. In a next phase
that lasted just over two centuries (1540-1758) they typically contained brief paragraphs
on the history of perspective. Beginning with Lambert (1859) some treatises have
contained short sections on the history of the subject but these have seldom been very
accurate and never approached any measure of comprehensive treatment. Encyclopaedias
have proved useful both for reprints of primary sources and general surveys of secondary
sources but these too have never approached a comprehensive treatment of the subject.

In the case of bibliographies (fig. 9), the number of books cited has grown slowly from
seven primary titles in Lomazzo (1590) to 1283 primary titles in Vagnetti (1979). If we
stand back to observe the patterns underlying this growth we can discern a gradual shift
in both the methods for recording and criteria for selecting titles. In the sixteenth,
seventeenth and early eighteenth centuries scholars were frequently content to cite a
single work by an author such as Alberti or Dürer, with little or no attention to different editions. Bibliographers such as Murr, Scheibel and Murhard transformed this tradition by focussing more attention on individual editions although the quest for comprehensive and exhaustive lists is only now becoming of importance. Until very recently, even the most famous scholars in the field such as Panofsky were content to make enormous generalizations about the history of the subject on the basis of having read a very small selection of the actual sources. For all these reasons a serious history of the subject has yet to be attempted for which it is hoped that the present study may at least provide a context.
III. VISION AND REPRESENTATION


1. Introduction

The history of perspective can be seen as a story of changing relations between theory and practice of vision and representation. In Antiquity theories of vision appear to have preceded theories of representation. In Greece, the earliest treatise on representation, according to Vitruvius, was by Agatharcus, followed by those of Democritus (c. 460-370 B.C.) and Anaxagoras (c.500-428 B.C., see appendix 1). Theories of vision began earlier and were dealt with in terms of four disciplines: physics, i.e. meteorology, (Aristotle), philosophy (Lucretius), mathematical optics (Euclid) and medicine (Galen). There were two main theories of how visual rays function: one claimed that rays go out from the eye (extramission), another that images come to the eye (intromission). Corresponding to these alternatives were two fundamentally different frameworks for understanding vision. One, linked indelibly with Plato, claimed that knowledge was basically innate and therefore did not require acquisition of new knowledge through visual stimuli. The other approach, challenged by Aristotle, held that there was nothing in the intellect which was not previously in the sense [of vision]. These two frameworks have been linked with various opposites: idealism vs. materialism; rationalism vs. empiricism; nature vs. nurture; intuitional theory vs. empirical theory, deductive vs. introspective, nativism vs. empiricism or to use modern jargon, analogue vs. digital images. In the history of psychology all these tend to be seen as different names for a single set of opposites. As will be noted below, philosophers and historians claim that they reflect at least two different oppositions.

While the two approaches associated with Plato and Aristotle are frequently reduced to simple polarities, it should be stressed that the details of each side are too easily lost in these dualities, all the more so because both sides have their own complex history in the course of which their methods become increasingly intertwined. The historiography of both sides also changes with time such that who ends up on which side also varies. By way of introduction, two examples will be cited to caution the reader that all such schematizations of the schools, including this one should be taken with a grain of salt. In the nineteenth century, for instance, when Helmholtz coined the terms empiricism and nativism to characterize these two schools he simply traced the tradition back to Kant. Subsequent authors, especially in the United States, have reversed the order of the presentation, speaking of nativism and empiricism and tracing the origins of these two schools back to Descartes and Hobbes respectively. Historically we know that Kant was an exceptional individual who set out to find a means of reconciling extreme formulations of these two sides. In the United States, where these polarities are taken more seriously, Kant, is treated as a nativist by Hagen (1980, cf. our fig. 14). We have already noted a similar approach in our discussion of Blatt (see above pp. 8-10*).
The best survey of these terms is found in an appendix by Hatfield (1990), who noted that philosophers insisted on (271): “a sharp separation between the genesis or causal origin of a thought or idea (innate or learned) and questions about the justification of knowledge (through reason alone or by appeal to sensory experience)”. Hence, philosophers distinguished two sets of debates nativism-empirism (*nativistisch-empiristisch*, a distinction introduced by Helmholtz) and rationalism-empiricism (*Rationalismus-Emprirismus*, two epistemological positions which emerged in the eighteenth century). By contrast, psychologists tended to conflate these two sets of oppositions to one.

For our purposes, debates concerning these two frameworks are of great interest for five reasons. First, they explain why some persons have recognized the independence of perspective from vision and even claimed the irrelevance of perspective for vision. Second, these debates bear on discussions whether or not the shape of the retina is significant in perception, a theme which has practical implications for artists who think that one might need to use spherical methods in order to draw correctly. Third these debates brought into focus a distinction between visual space and geometrical space, which dovetails with arguments about spherical vs. rectilinear images but also raises larger questions concerning subjective vs. objective and paradoxical trends to an objectification of the subjective especially in the United States.

<table>
<thead>
<tr>
<th>Period</th>
<th>Empiricists</th>
<th>Nativists</th>
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<tbody>
<tr>
<td>1600-1700</td>
<td>Hobbes, Locke</td>
<td>Descartes</td>
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<tr>
<td>1700-1800</td>
<td>Berkeley</td>
<td>Kant</td>
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<tr>
<td>1800-1850</td>
<td>-Hartley</td>
<td>Psychophysicism-Fechner</td>
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<td>Sensory Physiology-Young</td>
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<td>-Müller</td>
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<td>-Helmholtz</td>
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<td>1900-1950</td>
<td>Ames</td>
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<td>Transactionalism-Ittelson</td>
<td>Gestalt School-Koffka</td>
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<td>1950-1960</td>
<td>Constructivism-Gregory</td>
<td>-Köhler</td>
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<td>1960-1970</td>
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<td>-Werthheimer</td>
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<td>1970-1980</td>
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<td>-Arnheim</td>
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<tr>
<td>1980-1990</td>
<td></td>
<td>Gibson</td>
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Fig. 14. Key figures in debates between nativists and empiricists according to Hagen (1980).

Fourth, some of the complexities of this debate help us to understand why perspective has become so important for modern psychology, particularly in the school of Gibson. Fifth, there are ways in which these debates bear on the fundamental question of the status of perspective: is it merely a convention or does it represent an objective method? Each of these basic themes will be considered in turn.

2. Independence of Perspective From Vision

In Antiquity, members of the empirical school included Heraclitus (fifth c. B.C.), Protagoras, Empedocles, Democritus, Aristotle and Epicurus. They stressed the
importance of experience and that nothing could be known which had not come through
the senses (*nihil in intellectu quod non prius in sensu*). In the seventeenth century, this
idea was taken up by Hobbes (1651). In his work *On Man* (1658), Hobbes insisted that
the analogy between vision and images on screens of camera obscuras was false and that
the retinal image played no significant role in the process of vision, as Maurin (1974),
noted in an article which also referred to recent debates between Ronchi and Gibson. The
ideas of Hobbes were explored further by Locke (1690) who claimed that we begin life
with a clean slate (*tabula rasa*). Sensations in the eye were, however, only the first step
of a process. These were combined with their residues called images through the “laws”
of association, whence the name associationists for later followers of this school.

Berkeley (1709), took this approach much further by insisting that there could be no
direct sense of abstract distance, perception of far objects’ distances, convergence, of
near objects or perception of size. A two dimensional image on the retina was insufficient
to determine an object’s three dimensional situation. Hence perspectival effects of
distance (size perspective, linear perspective and atmospheric perspective) were
effectively irrelevant for the visual process, or so it seemed. This approach was taken
further by Hume (1739), the associationists, Hartley (1740) and Brown (1820) in
England, and subsequently Lotze, Helmholtz, Wundt and Titchener on the Continent.
Helmholtz, for instance, claimed that the shape of the retina ought not to have any effect
on the shape of the image which we see (see below p. 90), and as Boring (1942) recounts
he also explained (31):

> how people who lived only on a spherical surface would learn that all parallel
> lines intersect in two points, how people on an egg shaped surface would
eventually realize that circles of the same radius may have different
> circumferences, how men confined to a plane would never be able to get out of a
> square and how beings who had four dimensions at their disposal could step out
> of a sphere as easily as we can step out of a circle.

The same Helmholtz did important experiments to suggest that visual space may be
Riemannian and quite distinct from Euclidean space (see below). Hence, ironically, the
same empiricist school which insisted that all our knowledge comes to us through the
senses, provided a series of demonstrations and arguments suggesting that there could be
no simple link between outside world, projected images on the retina and what we see.
Since there was no easy physical explanation for vision, another explanation had to be
found. This is very important because it helps us to understand how what began as an
empiricist school could become linked with introspectionism.

3. Retinal Images

Evidence to the contrary came from unexpected quarters. In the late fifteenth century,
Leonardo da Vinci, had explored analogies between eye and camera obscura. Kepler
(1604), developed this analogy in his *Commentary on Witelo* (V.2): “I say that vision
takes place when the image of the whole hemisphere of the world in front of the eye and
even a little more, is formed upon the concave reddish surface of the retina”. This idea
which was soon taken up by Jesuits such as Scheiner (1619), who used real and model
eyes as camera obscuras to demonstrate the principle of inversion of images. The use of
camera obscuras as aids in drawing and painting was also well established by this time,
and there were even analogies between seeing and painting (cf. below pp. 122-127) and yet curiously enough, seventeenth and eighteenth century artists almost invariably assumed that they would be painting on a flat surface even though they saw on a spherical surface.

Ironically it was the tradition, linked with innate ideas since the time of Plato and given new life in the seventeenth century by Descartes, that played a key role in emphasizing the importance of retinal images. Descartes did much to characterize animals as reflex machines and to establish the notion that the senses could be treated as purely mechanical processes. Both Leibniz (1714) and Kant (1781) whose ideas are frequently linked with the nativist camp, helped in drawing attention to the retinal image.

Another nativist, the sensory physiologist, Johannes Müller, played an ambivalent role in this development. On the one hand his law of specific nerve energies stated that: “external agencies can give rise to no kind of sensation which cannot also be produced by internal causes, exciting changes in the condition of our nerves”. This potentially undermined further the importance of analogue type images in the eye, because any impression made by exterior physical images on the retina could be simulated by interior nerve stimulation. On the other hand, the links which he established between surface of the retina and nerve endings gave new impetus to explore these correlations precisely, as was done by Hering and Stumpf, who were linked with both the nativists and the phenomenologists in the tradition of Goethe and Purkinje. With the development of psychophysics by Fechner in the 1850’s the curved nature of the retina took on further significance. For since it was now claimed that every response was directly linked to a stimulus, one needed to account for what happened at and behind the retina, which became feasible through Ramon Y Cahal’s pioneering work on histology and studies of how the retina became linked with rods and cones. The nativists and phenomenologists eventually led to the Berlin school of Gestalt psychology.

Although it was particularly the nativists who focussed on the curved nature of the retina and the subjective aspects of vision in general, there was also interest from empiricists (cf. below p. 90*) such as Herrmann von Helmholtz, whose detailed studies of the eye revealed that visual space could on occasion perceive straight lines as curved. Although he himself concluded that this had nothing directly to do with the retina, his work sparked further research. Another empiricist, who became interested in these problems through unexpected circumstances, was the artist, A. E. Ames. As he reported in a later article (1921), around 1910, he was painting with his sister and believed that (22): “if they could make an exact reproduction in form and color of a scene they would have a technically satisfactory work of art”. To this end they made a set of thirty five hundred colored cards, but found that the results were “tight”, “hard” and lacking in atmosphere. This led him into a detailed study of optics including experiments on optical aberration and resulted in a scientific paper with the physicist C. A. Proctor. The authors (1921), made a careful survey of earlier work, notably Helmholtz, Donders, Drualt and Matthiessen, and found distortion in the eye greater than that: “due solely to the effect of the spherical shape of the retina...It can be concluded therefore that the distortion caused by the optical system is also barrel in its nature and increases that caused by the spherical shape of the eye”.

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These themes were taken up afresh by Ames, Proctor and Ames (1923) in an article entitled *Vision and the technique of art*. The authors acknowledged the pioneering efforts of the artist, Birge Harrison, who had shown “that a picture in its general form should be similar to our retinal impressions” 336. The authors explored analogies between the eye and camera, making photographs which they believed approximated the way the eye sees. The effects of chromatic aberration, spherical aberration and irregular astigmatism on the retina were discussed, as were effects of depth of field and distortion. It was claimed that the image on the retina of a rectangular grid would be barrel shaped (pl. 47.2), which: “causes straight lines that do not pass through the axis of vision, to be bowed outward in their central portions. It also causes objects away from the object to be imaged in smaller relative size than those near the axis” 337.

This led the authors to conclusions which help account for recent trends in variant perspectival methods particularly in the United States (see below 123*). It will be noted that Ames was also the inventor of the Ames room and related illusions which led to the development of transactionalism. These relied on perspective while calling into question its validity. Ames’ visual experiments were carried out at Dartmouth College where Luneburg, who cited him, carried out his studies of parallel lines (see below pp. 93-94*) and came to related conclusions about the Riemannian nature of visual space.

Borissalievitch (1923,1926,1950,1953,1955) used the spherical structure of the retina as a point of departure for his quest to find an optico-physiological method of perspective, which he believed also accounted for various optical adjustments methods in antiquity. The assumption that the spherical surface of the retina should determine directly the methods with which we represent the world inspired various architects and artists to devise a series of spherical projection methods, including Deininger (1914), Birker (1923), Jobin (1932), Möhrle (1941), Boaga (1948), Schumacher (1952), Flocon, Barre (1963), Bouligand, Flocon, Barre (1964) and others (see below pp. 122-126*). Interestingly enough most of these practitioners have been unaware of the optical, physiological and psychological literature either on the retina in general or on specific debates concerning geometrical and visual space.

4. Geometrical Space and Visual Space

Descartes’ (1637) *Discourse on Method*, while explicitly concerned with applying geometry to vision, also prepared the way for a mathematical treatment of the psychical and a psychology of the unconscious. Malebranche, in his *Research on Truth* (1674-1675), developed this Cartesian geometrical approach to vision and established a rationalist theory of vision emphasizing its inborn, innate qualities. Descartes’ study of apparent size and problems of visual space perception had intimated that there were potential discrepancies between perceptual space and objective space. Volkmann (1836), whose brother-in-law was Fechner, the founder of psycho-physics, suggested that there might indeed be discrepancies between perceptual and real space, and asked whether direction lines (*Richtungsstrahlen*) and visual rays (*Sehstrahlen*) coincided. Volkmann (1858), tried to show that they did. Hering (1862), came to very different conclusions. He claimed that visual directions (*Sehrichtungen*) had nothing to do with direction lines (*Richtungslinien*); that visual space was subjective and incommensurable with objective
space, i.e. relations of outer things with the surface of the retina. His colleague, Helmholtz, linked with the empiricists and the greatest optical expert of the nineteenth century, stated this more dramatically:

For my part I hold it as likely that it makes no difference at all to vision what shape (Gestalt), form, or position the retina has, what distortions the image suffers on its surface, as long as it is equally sharply impressed on the entire surface and neither the shape of retina or the image changes perceptibly with time. In the natural consciousness of an observer the retina does not exist at all.

This distinction between physical and visual space was restated by Mach in his *Analysis of Sensations* (1886):

The space of the geometrician is a mental construction of three dimensional multiplicity, that has grown up on the basis of manual and intellectual operations. Optical space (Hering’s ‘sight space’) bears a somewhat complicated geometrical relationship to the former. The matter may be best expressed in familiar terms by saying that optical space represents geometrical space (Euclid’s space) in a sort of relievo-perspective....The space of the geometrician exhibits at every point and in all directions the same properties- a quality which is by no means characteristic of physiological space.

In his subsequent *Knowledge and error*, Mach (1905) devoted an entire chapter to the differences between physiological and geometrical space. Physiological space like tactile space, he claimed, was non-metric, finite, anisotropic and non-homogeneous. By contrast, geometrical, Euclidean space was metric, infinite, isotropic and homogeneous. Hence there was a profound difference between subjective physiological space and objective, geometrical space.

Lambert (1774), in his treatise on perspective, had raised a related problem, whether the eye perceives painted space in the same way that it perceives physical space in the everyday world. With the rise of photography in the latter nineteenth century this question was reformulated: whether the eye perceives photographic space in the same way as physical space. In cases where a photograph was taken from a near point of view it was found that there were clear discrepancies and that a person viewing the photograph could not get his eye close enough to the picture in order to simulate the experience of the original physical space. To correct this problem, von Rohr (1905,1908), invented a special instrument (called a *Verant* in German), which aroused considerable attention at the time.

Psychologists, notably Aster (1906) and Jaensch (1911), studied conditions under which photographs could produce optimal effects of plasticity. Not everyone was convinced, however. In Italy, for instance, Ovio (1910) studied the properties of printed images seen from oblique angles. In Germany, Rudolf Peter (1921), in a fundamental study, which began by surveying this tradition since the time of Descartes, did a series of experiments to explore how individuals observed the space of photographs of paintings. He used a painting by Vermeer as his sample. Peter claimed that spatial relations can be established in painted space (*Bildraum*), but that the objects therein and their spatial values involve other relations than those in regular visual space. Both Mach and Peter were important
sources for the distinction between subjective and objective space made by Panofsky (see above p. 4*).

Peter’s concern whether or not visual space and depicted space coincide was taken up independently by Doesschate and Fischer (1937), who experimented with how individuals perceive perspectival drawings and found that a perspective drawing of single surfaced objects involves only a perception of space (Raumwahrnehmung) and no sensation of space (Raumempfindung). The authors concluded that one needed a three dimensional object in perspective in order to have a sensation of space. Doesschate (1951), pursued this problem in an article, On imaginary space in paintings, this time explicitly taking issue with Peter’s conclusions. He cited Van Mander’s anecdote that (47): “onlookers bet for high stakes whether there is a flat picture or a real object and how a German emperor often, by mistake, would pass through a garden painted by Paul Vredeman de Vries”. With his friend Fischer, Doesschate designed an apparatus to solve the problem experimentally. They concluded that: “it seems, though it is not proved, that normal and imaginary optical spaces are of the same origin and that they show the same structures”. Doesschate (1960) returned to these themes in an article on painter’s perspective. More recently Gombrich has defended this view in a lively debate with Gibson who claims that physical space and depicted space evoke very different visual experiences (see below p. 95*).

Zanetti (1968) considered the assumption that the geometry of visual field was a non-Euclidean elliptical or a hyperbolic (Lobatchewsky-Bolyai) projection but concluded that it was a Euclidean projection in keeping with the laws of linear perspective (cf below p. 124*). The problem of visual space vs. geometrical space was also explored by Ronchi (1971, 1974), who distinguished between the apparent world and the real or geometrical world, pointing out that the “contraction of the apparent world is much smaller than the real one”. He noted that classical optics had been concerned more with the geometrical world than with the actual experience of the visual world and proposed a new optics to deal with this.

At the turn of the twentieth century some individuals such as Daublebsky v. Sterneck (1906, 1908), were trying to bridge the gap between this supposed opposition by insisting that every point in visual space corresponded to one in real space and pointing to the visual angles law. This led (1910) to study of real and apparent monocular directions of sight. The result of these explorations of relations between visual and objective space was a series of comparisons: objective size with apparent size; objective distance and apparent distance; apparent size and apparent distance; objective direction and apparent direction. These debates brought into focus a series of six basic problems which were, and in many cases still are, seen either to prove or disprove the links between geometrical and visual space, namely the curved nature of the retina; the moon illusion; apparent curvature of the heavens; the apparent curvature of beams from a lighthouse, moving past consecutive objects and the perception of parallel rows. The first of these has already been considered above. The rest will be considered in turn.

Moon Illusion

Already in Antiquity, authors had noted that the apparent size of the moon is larger at the horizon than when seen above against the vault of the heavens. Both Aristotle (fourth c.
B.C.) and Ptolemy (c.150) explained this in terms of refraction. Sabra (1987) has studied Alhazen’s contribution to this problem.

The best single article on the subject remains Clarapède (1906), who began with a review of nine basic theories concerning the apparent size of the moon: 1) refraction (Aristotle, Ptolemy, Destréfano 1865); 2) dilatation of the pupil (Gassendi 1642, Stroobant 1865); 3) drop of the crystalline (Schaehrle 1899); 4) comparison (attributed to Descartes by Molyneux 1687, Helmholtz 1866); 5) contrast (Lühr 1898); 6) direction of vision (Gauss 1830, Stroobant 1884, Zoth 1890, Gutmann 1903); 7) overestimation of the angles (Zehender 1899); 8) feableness of peripheral visual acuity (Bourdon 1898); 9) greater distance of the horizon which is linked with three variables 9a) interposed objects (Ptolemy, Alhazen, Witelo c.1270, R. Bacon, Kepler 1604, Descartes, Malebranche 1675, Biot 1810, Wallis 1686, Huygens, Kundt 1863); 9b) aerial perspective (Alhazen, Witelo, Berkeley 1709, Le Cat 1744, Dunn 1762, Euler 1772, Biot 1810, Helmholtz 1866); 9c) shape of the heavens (Alhazen, Witelo, Malebranche, Hobbes 1658, R. Smith 1738, Mairan 1772, Brandes 1827, C.E. Schmidt 183*, Kämmtz 1836, Zeno 1862, Helmholtz, Blondel 1888, Wundt, Filehne 1894, Reimann 1902).

Clarapède observed that to him, and Molyneux, the moon seemed nearer when seen above against the vault of the heavens, but since this contradicted the majority of other authors he accepted that one needed another explanation which he sought in “the impression we have that the stars at the horizon, notably the moon, are terrestrial objects”339. To test this idea he asked 20 individuals to compare the relative sizes of two moons (actually the same size) in a drawing, one near the horizon, the other high in the sky, and found that 14 perceived the one on the horizon as larger, five perceived the two as equal, while one saw the moon at the horizon as smaller than the one in the heavens. In a postscript, Clarapède noted that Bourdon (1905) in an analysis of an important study by Mayr (1904) had independently come to the same conclusions, namely that we see objects in the sky as if they were terrestrial objects when they are at the horizon. More recently the problem was taken up afresh by Kaufman and Rock (1962), who used photographs as well as drawings in their tests. Their conclusion was (268): “that the moon illusion depends on the presence of terrain and specifically on the distance effect of the terrain. Eye elevation, color and apparent brightness evidently have nothing to do with the phenomenon”.

**Apparent Curvature of the Heavens**

The apparent concavity of the vault of the heavens was a well-known phenomenon. The Oxford English Dictionary traces English usage of the term to 1591. The astronomer Schickhardt noted that although the course of a comet appeared to be curved it was in fact rectilinear. He also suggested the implications this had for art (see below p. 122*). Filehne (1895, 307), in a significant essay, which included an historical survey of the problem, traced the notion of the curvature of the heavens as a conic section back to Hobbes. He traced the competing view of the heavens as a half ellipsoid back to Smith (1755). He noted that Smith’s calculations were partly adapted and partly simplified by Drobisch (1854), who was among the first to pose the problem in a way that could be experimentally tested. Fechner (1859) discussed the apparent size of the stars as an example of his so-called law of psychophysics.
Reimann (1890-1891), made a first attempt to quantify this apparent curvature and suggested that the atmosphere was a factor in this subjective experience. Zoth (1899) suggested direction of sight played a role in both the apparent form of the heavens and the apparent size of the stars. Mach (1908) claimed to have observed luminous rays of the setting sun passing through holes in the clouds which appeared to be curved and reunite at a point opposite the sun.

Daublebsky von Sterneck (1906), taking as his point of departure Helmholtz’s descriptions concerning psychological aspects of the vault of the heavens, provided more quantitative data concerning its apparent curvature. That same year (1906) he proposed a theory of apparent distances. Two years later he also proposed a theory for the apparent curvature of the heavens and apparent size of the stars, which led (1908) to a more general theory of visual space (see next section). The same v. Sterneck (1908), challenged by Meinong’s psychophysical “law”, whereby differences in stimulus (Reizverschiedenheiten) were matched by differences in response (Empfindungsverschiedenheiten), constructed experiments which he believed confirmed this.

Witte (1918), studied these questions and claimed that objects at infinity appeared to be at a distance of ten kilometers by day, whereas by night everything that was beyond 100 meters appeared to be on a curved surface (see also next two sections). Müller (1918) made the most thoroughgoing study to date of two related problems: the apparent vault of the sky by day (Referenzfläche des Himmels) and of the stars at night (Referenzfläche der Gestirne). He began with a review, complete with mathematical equations, of three types of apparent vault: section of a sphere; section of a paraboloid and half an ellipsoid. A review of major contributions followed including Reimann (1890, 1891), von Sicherer (1904), Figee (1906), A. Müller (1905 etc.), Ernst (1904), Nijland, Bourdon (1899) and von Sterneck (1906, 1907). With reference to the vault of the heavens he identified a series of factors: day and time of the observations, visual angle, saturation of the colour of the blue sky, kind and density of the clouds, distance of the horizon, range of visibility, direction of the heavens and characteristics of the landscape. In the case of the apparent size of stars he listed as additional factors: height, colour and intensity of the star, general condition of the air, and characteristics of the horizon: i.e. whether it be lined with trees or houses. Müller considered both physiological and psychological aspects and referred also to related experiments involving beams from a lighthouse and parallel rows. More recently Barthel (1953) has broached problems of apparent curvature of the heavens in a popular article.

**Apparent Curvature of Light from a Lighthouse**

Apparent curvature of light from a lighthouse emerged as a special instance of the larger problem concerning apparent curvature of the heavens. Bernstein (1904) reported on a lighthouse on the island of Helgoland of which the electric lightbeam could be seen to the horizon. Having observed the apparent curvature of its beams under various conditions Bernstein claimed that one needed to make a distinction between the space of visible objects (Raum der sichtbaren Objekten) and the space of observation (Raum der Anschauung). As he pointed out, these findings raised questions concerning Reimann’s (1890-1891) claims that atmospheric effects alone could account for the shape of the
heavens. Bernstein noted that both Gauss (1880) and Zoth (1899) had mentioned direction of sight as a factor in this phenomenon and added a further complicating factor of his own. If one stands on a hill the direction of sight does not alter substantially with respect to the horizon. Nonetheless, the zenith appears closer and the heavens appear flatter whether the hill is twenty, fifty or one hundred meters high.

Doesschate and Fischer (1939), returned to this problem citing their own experiments with the beacon at the airport in Soesterberg. They discussed the problem of apparent curvature of the heavens, cited as insufficient Dunoyer’s explanation in terms of curvature of the retina and the distortion of images seen in indirect vision, and proposed instead that it was due to the reduced dimensions of optical or visual space which did not exceed 100 meters.

**Moving Past Consecutive Objects**

Plateau (1880), studied consecutive images and concluded that optical space did not exceed 51 meters. Doesschate and Fischer (1939), did related experiments looking at luminous sources from a moving automobile and found the limits of visual or optical space to be between 50 and 60 meters.

**Parallel Rows**

The problem of how parallel rows are perceived emerged in the seventeenth century in the planting of trees. Fabry claimed and Taquet believed he had demonstrated that one needed to plant trees in the shape of two opposing hyperbolic rows in order that they appear parallel. In the early years of the eighteenth century Monsieur Carré of the French Academy brought the passage of Fabry to the attention of his colleague, Varignon (1720) who, aware also of Taquet’s demonstration, offered a more general solution of the problem using the analysis of sines of various visual angles, but came to no clear conclusions. These claims were reviewed in an anonymous (1720) article on the parallelism or apparent non-parallelism of rows or alleys of trees. In England, Robert Smith (1738), in his *Compleat system of optics*, attributed a similar claim to his friend Martin Folkes. In France, Bouguer ([1755],1767), of photometry law fame, linked Varignon’s claim with Malebranche’s theories and established that two rows of the trees appear parallel if they are planted in the form of two opposing hyperbolas. He also showed how straight lines could appear curved. According to Doesschate and Fischer (1939, 105), Bouguer was thus the first to describe apparent curvature of visual space and explain it through under-estimation of distance.

In the early twentieth century, this problem was taken up afresh by Hillebrand (1902), in his alley experiments. Rows of light points were so arranged that they appeared to be parallel and no longer seemed to converge. The resulting divergent curves were found to be comparable to an hyperbola. Sterneck (1906), also concerned with curvature of the heavens, was stimulated by Mach’s (1905) distinctions between geometrical and visual space, to develop a theory of apparent distances. Citing Hillebrand’s studies and a series of his own experiments, Sterneck suggested that these phenomena could be explained through a basic underestimation of distances for which he offered a formula. This led to more comprehensive psychological studies on *Visual space as a result of experience* (1907), in which he developed his theory of apparent distances, again showing its relation
to Hillebrand’s results, with a section on the apparent curvature of the heavens and apparent size of the stars, plus a section on the apparent steepness of mountains. Poppelreuter (1910) explored these problems. Blumenfeld (1913), repeated Hillebrand’s experiments under better technical conditions with similar findings concerning parallel alleys. In addition, when he asked observers to set up alleys of equidistant walls, he found that in the distance alleys a) did not appear parallel and straight and b) that in the distance alleys appeared to lie outside the parallel alleys.

These experiments, as well as the horopter experiments of Helmholtz, served as a starting point for Luneberg (1948), who distinguished clearly between visual space and physical space and attempted to express both in mathematical terms. He claimed that while physical space was Euclidean (240): “the visual space of binocular vision is a hyperbolic Riemannian space.” He was careful to note that while qualitative agreement between theory and experiment was ensured, a systematic quantitative test had still to be made. Luneberg (1950), developed these ideas claiming that visual space has a uniquely determined non-Euclidean metric or psychometric distance function (627): “which varies in its numerical parameters from observer to observer. But its general form is invariant; it is the metric of the three-dimensional hyperbolic geometry”. In this paper Luneburg removed the restriction on freedom of observation and for the first time introduced a “probable mathematical function involved in motion.” Hardy (1949) restated the findings in more dramatic terms (560):

The theory, then, is that visual space differs from physical space; that if the latter is Euclidean in our vicinity the former is certainly not; that the metric of visual space closely corresponds to, or is identical with, the metric of Lobatchewsky’s hyperbolic geometry; that at least two and probably more, personal constants enter into this metric; that these constants (like refractive errors, aniseikonia, stereopsis, etc.) are fairly stable for a given individual but may be modified by such factors as age, correction of refraction, experience, and other factors; that they are probably also closely related to his mechanical and artistic skills and that they may eventually prove to have considerable predictive value in regard to personell selection for special tasks.

Luneburg’s student, Boeder (1957), restated these ideas in an article on the theory of visual space as did his follower, Blank (1959). Not everyone agreed. In the Netherlands a series of experiments on the perception of parallels by Doesschate and Kylstra (1955) found some surprising characteristics but noted that “no one among our subjects observed an apparent curvature of the lines”. Doesschate (1959) raised the question whether Cezanne had anticipated Luneburg’s claims. In the United States, Luneburg’s claims were questioned by psychologists such as Graham (1951) and Ogle (1962). In England, they were challenged by Pirenne (1975). In the United States, they were subsequently proven wrong as noted by Heelan (1983). No simple mathematical formula for subjective dimensions of vision has been found. Even so, the fundamental distinction between the visual space and geometrical space is largely accepted. It is a starting point for J. J. Gibson’s distinctions between visual field and visual world.
5. Gibson’s Distinctions

Gibson’s (1929) published work began with an experiment on the perception of drawings. Gibson (1933) took as his point of departure Stratton’s work on new space habits as a result of wearing glasses which distorted the visual field. Instead of a lens with curved surfaces, simple prisms were used. Gibson found (27) that when a curved line has been perceived for any considerable length of time, it becomes phenomenally less curved than it was at first, and also that after such a period of fixation or inspection, a straight line appears distorted with an opposite curvature. This lead him to conclude that (31): “there is a system of point to point corellations between retinal field and phenomenal field but that it is not a rigid system”

Gibson (1950), claimed that empty space was irrelevant for the theory of space perception and proposed that the fundamental sensations of space were (367) “impressions of surface and edge”. He offered a tentative list of eight essential properties in experiencing a determinate surface: 1) the property of being visually resistant or hard; 2) the qualities of extended colour; 3) the property of being illuminated or darkened; 4) the quality of slant; 5) the property of nearness or farness or distance; 6) the impression of a closed contour; 7) the quality of shape-at-a-given-slant and 8) the quality of size-at-a-given-distance. The main body of his paper focussed on the problem of texture gradients and led him to conclude (384):

The perspective of texture, as distinguished from the perspective of rectilinear outlines, seems to be a fundamental basis for the impression of a three dimensional environment, or what has been called space. The results of this experiment suggest that the property of the slant of a surface can be assigned a correlate in retinal stimulation, and that perhaps other properties of the phenomenal environment can be similarly accounted for when an appropriate psychophysical method has been applied to them.

This article heralded themes which Gibson (1950) developed in his first major book *The perception of the visual world*, themes which were important for at least two reasons. First, his emphasis on lines and contours has become one of the major themes of Gibson’s student, Kennedy (see below pp.). Second, his work on texture gradients has spawned a whole subsequent literature, which has since been reviewed by Haber (1974).

Gibson (1952) made a useful distinction between the visual field and the visual world. Boring (1952), in an important article, claimed that there is a complex way in which the entire tradition of two schools provides a larger background for Gibson’s distinctions. The debate between empiricism and nativism can be seen as one between sensation and perception, between operationists (or operational behaviorists) and phenomenologists, which has its nineteenth century roots in a debate between the Leipzig school of Wundt-Titchener and the Berlin school of the Gestaltists. They disagreed about what was immediate and what was mediate. The Leipzig school held that sensations, contents and existential processes were immediate and that from these came derived entities such as knowledge and meaning. The Berlin school claimed that objects were immediate and that sensations, contents and existential processes were derived from these by inference and abstraction. The Leipzig school focussed on the reduced, unstable space of visual geometry; the Berlin school was concerned with the unbounded, stable space of
Euclidean geometry. Stated in naive terms, Leipzig was concerned with what we see: Berlin with what we know, the old debate of world of appearance and world of reality in a new guise.

Leipzig: Wundt-Titchener
Immediate: Sensation, Contents, Existential Processes
Mediate: Knowledge, Meaning
Visual Field
Reduced, unstable space of visual geometry

Berlin: Gestalt School
Immediate: Perception, Objects
Mediate: Sensation, Contents, Existential Processes
Visual World
Objective, stable space of Euclidean geometry

Fig. 15. Dichotomies implied by the Leipzig and Berlin schools and reflected in Gibson’s work according by Boring (1952).

According to Boring, the concerns of the Leipzig school became Gibson’s visual field; those of the Berlin school were reflected in his concept of the visual world (see fig. 15). In reply to Boring, Gibson (1952) took up the example of railroad tracks extending to the horizon. In one sense they are “seen” to converge in a perspectival sense. This Gibson termed the visual field. In another sense they were “seen” not to converge. This Gibson termed the visual world. Boring had suggested that the visual field was a reduced form of the visual world. Gibson insisted that they were different, or as he later (1966) claimed, alternative ways of seeing. Boring (1952), replied that he did not understand the visual field. There were good reasons for this confusion. At this stage Gibson was only implicitly making a connection between the visual field, (traditionally termed visual space), and perspectival images made by artists. To complicate matters, he was gradually revising his definitions of both perspective and pictures. Already in his Perception of the Visual World (1950), Gibson was clear that perspective did not provide a simple stimulus, as he recalled later (1971, 28): “The perspective of surface texture is not shown, only what are called outlines. In both cases note that it is the optic array that is the stimulus, not the image”.

Gibson, Olum, and Rosenblatt (1955) identified four cues were needed to see the distance of a given object in space: binocular parallax or disparity; linear perspective; aerial perspective, superposition, shading; and motion parallax. They showed that the accepted formulation of motion parallax was insufficient, and offered a more general description in terms of motion perspective, analysed mathematically in terms of the optical flow-pattern reflected from a surface to an eye. They concluded that if these variables were stimuli for perception they (385):“can determine not only the experience of a stable tridimensional world, but provide a basis for the judgments required for the control of locomotion in that world.” Gibson (1960) greatly expanded the traditional meaning of perspective:

It is possible therefore to think of perspective as a more general science than the rules of representative drawing, or the description of visual sensations or even the transformations of forms on one abstract plane to forms on another plane. It would be the geometry of the ways in which the light is reflected. Linear perspective of the classical sort would be only a small part of it, for that is merely the perspective of the edges of rectangular objects. There is also the perspective of the textures of inclined surfaces, the gradients of texture-density, the steps of
density at the edges of objects, the ratios of densities in different directions and still other variables of higher order.

Above all there is the perspective of change of position as distinguished from the perspective of position. When the station point moves, the whole structure of the optic array undergoes transformation. A new set of variables arises to confirm the information in static perspective. The parameters of transformation are specific to the motion of the station point; the invariants under transformation are specific to the permanent properties of the environment. The optical array has a unique structure for every station point in the world. And the change in structure of the array is unique for every change of station point in the world. This is essentially what is meant by saying that ambient light carries information about the world.

As Gibson’s ideas developed his concept of a picture changed also. When he wrote his *Ecological optics*, Gibson (1979), recorded four stages in this development. A first attempt in Gibson (1954) defined a picture as (270-271): “an array of pencils of light coming to the pupil of an eye such that each corresponds in brightness (and hue, if any) to its radiating element of the picture surface”. In Gibson (1960b) this was revised to “an array of nested visual solid angles at the station point determined by steps or contrast of intensity and spectral composition of the ambient light”. In Gibson (1966b) a picture was redefined as “an array considered as a stationary structure”, which was then modified in Gibson (1971) to “an array of persisting invariants of structure that are nameless and formless”.

Gibson’s description of the contrast between the visual field (sensation) and the visual world (perception) shifted also. In *The senses considered as perceptual systems*, Gibson (1968), suggested (236): “that men had not paid attention to the perspectives of things until they learned to draw and to perceive by means of drawings”. Hence the making of pictures led persons to discover that they had sensations. At the same time he made bold to suggest (237):“that the data for perception, the invariants of available stimulus information, were quite independent of the data for sensation, the retinal images considered as pictures”. He also discussed two conceptions of information: one, was information about, which permits perception of, the other was information as structure, which allows perception as discrimination.

In an article on “The Information Available in Pictures”, Gibson (1971) took to task Goodman on the analogy between visual and verbal images. Gibson accepted that both pictures and language could be said to have structure and even a sort of grammar, but insisted that (34) “the informative structure of ambient light is richer and more inexhaustible than the structure of language”. Gibson (1979,285) developed this distinction: “The essence of a picture is just that its information is not explicit. The invariants cannot be put into words or symbols. The depiction captures an awareness without describing it. The record has not been forced into predications and propositions”.

Gibson (1971) also claimed that there were two basic theories of pictures: a point-projection theory and a symbol theory of pictorial information, linked with the ideas of Kepes and Goodman. The point-projection theory was based on perspective and assumed that a “picture can stand for a real object or scene insofar as the rays from the picture are the same as the rays from the real object”. The symbol theory claimed that pictures are
symbols which one needs to learn to read much as one needs to read written speech. Gibson rejected both theories and presented his new theory based on the assumption that light can convey information about the world: “This theory makes it possible to distinguish between the pictorially mediated perception of the features of the world and direct perception of the features of the surroundings and yet understand that there is common information for the features that they have in common”.

This deserves further explanation. As we have shown there was a traditional distinction between subjective visual space and objective geometrical space. In his early writings Gibson argued that we actually see both. Hence his distinction between the (subjective) visual field and the (objective) visual world. He now argued that the visual field was irrelevant, that what we see is the visual world and that: “the basis of this direct perception is not the form sensations, or even the remembered sequence of these forms, but the formless and timeless invariants that specify the distinctive features of the object. These are the information for perception”.

He called his new theory ecological optics. In his early work Gibson had linked pictures with the visual field. His rejection of the visual field did not, however, lead him to reject pictures because he now insisted (31): “that an informative picture contains the same kind of timeless invariants that a sequence of perspectives contains”. Gibson (1979), developed these ideas in *Ecological optics* where he claimed that: “if a picture displays the perspective of a scene it puts the viewer into the scene, but that is all. It does not enhance the reality of the scene....The advocates of perspective representation are mistaken, but those who reject perspective as a mere convention are also mistaken”.

Gibson also distinguished sharply between linear or artificial perspective as he termed it, and natural perspective of the optical array (283): “Artificial perspective leads to a set of prescriptions for producing virtual streets, buildings and interiors seen from from a fixed position and a corollary requiring that the painting be viewed with one eye at a unique station point. Natural perspective leads to ecological optics and the concept of the invariant structure in a changing optic array”.

In answer to the question: what does it mean to see in perspective? Gibson now suggested a further distinction between patchwork perspective and edge perspective. He argued that drawing in perspective requires only edge perspective “whereas patchwork perspective is a myth. One can learn to draw the former but not to see the latter”. Hence line drawing could specify some invariants of surface layout (a corner, edge, occluding edge, wire, fissure, and a skyline) but not others (shading on a curved surface, penumbra of a cast shadow, texture of a surface, or reflectance of a surface). Already at an early stage, Gibson (1971), had insisted that a picture could not be a substitute for reality. This idea he now restated more dramatically (1980, 291): “A picture requires two kinds of apprehension, a direct perceiving of the picture surface along with an indirect awareness of what it depicts. This dual apprehension is inescapable under normal conditions of observation. The fooling of the eye, the illusion of reality, does not then occur”.

Gibson (1980) pursued this distinction in his last work, “A Prefatory essay on the perception of surfaces versus the perception of markings on a surface”: “Surfaces have the kind of meanings that I call affordances, whereas marks on a surface can have referential meanings; that is, the marks refer to something other than the surface itself. A
surface does not stand for anything”. In this Socratic essay, which raised many more problems than it solved, Gibson (1980, xv-xvi) listed at least ten different meanings for the term image: 1) solid; 2) pictorial; 3) arrested; 4) mirror; 5) camera; 6) photographic; 7) retinal; 8) afterimage; 9) memory; 10) mental image. Gibson’s complex work has been cited in detail because he has been central to a number of recent discussions and helps us to understand various developments: why, for instance, psychologists should have become so interested in the perception of pictures (e.g. Hagen 1980); why psychologists now emphasize textures and gradients as part of a quest for invariants and structure; why there is so much emphasis on line drawings (see below p. 139*). Gibson’s work also helps us to appreciate why perspective has become so central to psychological debates. What was seen by many as a method linked only with the subjective visual field has now been linked equally with the objective visual world. As a result while Gibson’s work has played a role in the development of virtual reality thus linking perspective with new realms of subjective phantasy (see below pp. 138-139), he has also shown that perspective is much more than a convention, and has helped to revive interest in the status of perspective as an objective method.

6. Status of Perspective

In the fifteenth century, when the rules of perspective were not yet well understood, perspective had various detractors as Piero della Francesca noted in his *Perspective of Painting*. Nevertheless, both Piero and his younger contemporary, Leonardo da Vinci, were at pains to demonstrate that perspective was based in experience and could be demonstrated mathematically. Sixteenth century authors saw perspective as an important element in their search for causes (cf. above p. 2*). After the demonstrations of Guidobaldo del Monte, Stevin and Desargues, it was generally assumed that perspective was an objective method important for both mathematics and science. Hence the prominent role it played in an illustration of the French Academy of the Sciences and on the title page of Newton’s *Optics* (1740). This assumption continued into the twentieth century as evidenced by Wyllie (1903, p. 195) who claimed that perspective: “is an exact science; and the majority of its rules can be demonstrated with absolute certainty, so that they can no more be disputed than the multiplication table or the propositions of Euclid”.

The development of a clear distinction between visual space and geometrical space in the nineteenth century introduced serious problems for the traditional view that linear perspective corresponds both to what we see and what is there. As we have noted (above p. 54*) Florenskij (1919) used this as a starting point for his claim that linear perspective was but one of many possible methods. Panofsky (lecture 1924-1925, published 1927), was the most famous author of the time to assume that linear perspective must correspond to geometrical space, but was then led to suggest that curvilinear perspective corresponded to visual space. Hence while he did not question the objectivity of linear perspective he brought into discussion its being but one among other methods.

It is important to recall that a number of (now often forgotten) authors were making similar claims. Riehl (1926, 1961) in an article on “Kinds of Perspective” pointed out how Cezanne, Gauguin, Van Gogh and their followers had pushed the old perspective aside and had destroyed the notion that there was only one correct perspective. Riehl noted that there were at least four reasons why this happened: the spiritual component
geistige Anteil) in a picture; the problem of form, the making of images on the surface of a picture; opposition between painting surface and spatial depth and the problem of binocular vision. He listed a series of alternative responses to these problems ranging from the aspective methods of Egyptian art to parallel perspective, concluding on an optimistic note that there remained unlimited new possibilities with which to experiment.

Thouless (1930) in an article entitled The Truth about Perspective? asserted that (121): “we see objects not in the shapes demanded by the laws of perspective but as a compromise between these and the shapes we know that they have in physical reality”, which provoked correspondence with Hughes and Boxsius (1930). Thouless (1970), considered another alternative (133):

an experimental situation in which the retinal image remains constant and the reality changes. What is then observed is not that the appearance remains constant but that this changes in the same direction as does the real character of the object. This result seems to point to a “compromise” explanation rather than a “constancy” one.

Blanché (1946), ten years before Gombrich claimed that: “Linear drawing even when it is correct as far as perspective is concerned can only with difficulty pass as a manifestation of visual realism.... Drawing has the intellectual character of a schema rather than the sensible character of a copy.” Blanché cited examples of alternative methods in the orient: “Hence our system does not have that universality that we were tempted to accord it”; mentioned the difficulty that children have even in recognizing perspectival rules and applying these when they learn them; distinguished between visual perspective and geometrical perspective, yet maintained that artists reproduce what they “see” while making clear that no artist sees the same, concluding: “For the artist it is not so much a question of painting what he sees as arriving at seeing something which can be painted and which is at the same time worthy of being painted to make for himself, in other words a visual reality that is at once delectable to the eye and transposable to the canvas.”

Wald (1950), argued that the old analogy of eye and camera was still valuable: that both use a lens to focus an inverted image on a light sensitive surface; both possess an iris to adjust to various intensities of light, and both relied on chemical processes. Wald cited examples of optograms, images that had been photographed on the retina. This was an exceptional position. Francastel (1951,7), in an influential book, claimed that linear perspective: “is a conventional method of expression based on a certain conditions of technology, science and of the social order of the world in a given historical moment”. Michel (1952), distinguished between visual, constructed and translated space (used in painting). He followed Francastel’s view that perspective was a convention and took up Grabar’s notion of the intellectual symbol whereby a vision of the soul destroys perspectival space. Kentzler (1954-1955), discussed the limits of perspectival construction. Bandmann (1956) believed that perspective was now only one form among many used to characterize western art from the eleventh to the nineteenth century. Zanetti (1960) attacked the views of both Benevolo (1960, 151), who had claimed that “perspective is based on an intellectual notion of reality similar to the Cartesian one of res extensa” and Francastel (1951), insisting that perspective had a basis in objectivity.
Kentzler (1954-1955), explored parallels between optical and acoustical ratios; claimed that the limits of undistorted perspective were within an angle of 30 to 40 degrees; that the eye had a hyperbolic image, whereas perspective had a plane image. He consequently suggested combinations of cylindrical and spherical perspective to approximate effects of vision. Malecki (1961) claimed that linear perspective, with its emphasis of a single viewpoint was a particular manifestation of the Renaissance in western culture, that eastern cultures had developed parallel perspective, that the middle ages had its own variants and that twentieth century art was a rejection of the constructed position of a single viewpoint. Merleau Ponty (1961) in an article entitled “Eye and Spirit” cited Panofsky and claimed (210): “The truth is that no method of expression acquired resolves the problems of painting or transforms them into technique because no symbolic form ever functions as a stimulus....Renaissance perspective is not an infallible trick: it is but one particular case”.

Adams (1962), explored the problem of naturalistic painting. He noted how nineteenth century artists often explained this in terms of retinal images and perspective. He cited Ames (1923) as a climax of this tradition which he criticized for two errors: that painters are (35) “concerned with producing a single retinal image in the spectator” and “that the picture itself must resemble the retinal image”. He therefore rejected the idea of making curved images (see below pp. 96-100* ). Adams’ own explanation for naturalism was (36-39):

the more the perceptual mechanisms used in constructing the picture space operate in their normal manner, the more naturalistic will be the picture....It does not follow from our hypothesis that only one naturalistic treatment is possible for any given subject....An artist can, through his painting, select among alternative sets of cues, which would give rise to the same spatial interpretation.

Adams (1972) explored the question of “Perspective and the viewpoint” and concluded (217): “The depth of perceived space falls short of that predicted by geometrical hypothesis. The results do not confirm current assumptions about the importance of the mode of viewing. Monocular and pinhole viewing, although they may increase the likelihood that the viewer will experience a full illusion of space, do not increase the apparent depth of that space”.

Meanwhile, Heymann (1962), asserted that three dimensionality depended on a combination of kinaesthetic, haptic and optic experiences which led to three-dimensional perception structures (Wahrnehmungs-gestalten) and then to a three-dimensional imagination structure (Vorstellungsgestalt). He argued that cave paintings of France and Spain might be looked at as technical drawings made for practical purposes. Whether a painting was abstract or concrete depended on the relative optical vs. haptic-kinaesthetic components. Rzepinska (1964), took up Panofsky’s question of perspective as a symbolic form. The fact that it was part of Renaissance style did not deny its objective scientific values. On the question of curvilinear perspective she asked: if scholars claimed that linear perspective was a convention why then should curvilinear perspective be an objective truth? Bartke (1974), asked rhetorically whether perspective was outdated, noting that there were many examples of contemporary art in the German Democratic Republic which confirmed its continued significance notwithstanding the rise of
subjective-idealist ideologies which had brought irrational views to art and challenged the validity of laws of perspective. He intimated that these laws changed with the advent of photography. Ronchi (1971, 1974), in his discussions of new optics noted that the contraction of the apparent world was much smaller than the real world and thus distinguished also between visual perspective and geometrical perspective. De Chapeaurouge (1975), disagreed with Novotny (1938), who had described perspective as if it had gone unquestioned from the Renaissance until the Impressionists and drew attention to an ongoing conflict between perspective and importance scale (Bedeutungsmassstab), i.e. between optical appearance, significance and truth. Trapp (1977), linked perspective with mimesis but then noted that all art is mimetic.

In the United States, Snyder (1979-1980), took as his points of departure Gombrich (1960) and Panofsky (1927) to claim: “If there is a paradigm inherent in the invention of linear perspective, as Panofksy urges us to believe there is, it is the model of vision as picture. What Alberti accomplished was not the objectification of the subjective, but rather the externalization of the internal”. Kaori Kitao (1980) examined Kepler’s (1604) distinction between imago and pictura as a separation of perception from his optics and separation of his science from art. Kubovy (1986), while arguing that perspective was an invention, argued that it could not be dismissed as a convention because of the robustness of perspective, its ability to convey information even when not seen from the original vanishing point. One result of these many views was the emergence of an important debate whether perspective is a convention or an objective method.

**Perspective as a Convention**

As noted earlier Florenskij (1922), citing Mach’s comments concerning the limitations of linear perspective, referred to it as a symbolic form (two years before Panofsky’s lecture and) five years before Panofsky published his *Perspective as a Symbolic Form*. Panofsky’s position was complex. As was noted (p. 4*) Panofsky (1915), initially began from the assumption that perspective was the basis of objectivity and rightness in a painting. Further study, particularly the work of Blumenfeld (1913) and Peter (1921), convinced him that while linear perspective produced objective relations between object and represented image, this did not (necessarily) correspond with the subjective image seen by the eye, to which the curvilinear methods of Antiquity corresponded more closely. At the same time, Panofsky’s neo-Kantian assumptions led him to believe that each era had a given world view, theory of vision and representation. He argued that the Greeks had employed a method of spherical perspective. Hence while holding that linear perspective was objective, in that it was the only method to produce an accurate mathematical link between object and representation, Panofsky (1927), implied that it was an alternative to spherical perspective and thus implicitly claimed that linear perspective was a convention rather than an absolute system. Panofsky returned to these ideas in his later writings (1938, 1940, 1943, 1953), as did Bunim (1940), and White (1949-1951, 1957) who added more confusion than clarity through his restatement (see above p. 5*).

This idea was repeated by Sir Herbert Read (1956, 66) in a sentence which Gombrich subsequently attacked: “We do not always realize that the theory of perspective developed in the fifteenth century is a scientific convention; it is merely one way of
describing space and has no absolute validity”. Florenskij and his formalist circle had also developed ideas of perspective as a language (cf. above pp. 53-54*). This analogy was taken up by the structuralists and developed in the United States through Kepes (1944) and later Goodman (1968), who asserted that perspective was merely a symbol. Goodman’s understanding of technical laws of perspective was minimal as when he claimed (16): “By the pictorial rules, railroad tracks running outward from the eye are drawn converging but telephone poles (or the edge of a facade) running upward from the eye are drawn parallel. By the laws of geometry they should be drawn converging”. Goodman appears not to have understood that objects in the same plane as the picture plane do not change in size, (i.e. objects higher or further to the side), only objects in different planes. Nonetheless, Goodman attacked the views of Gombrich and Gibson to claim that (19): “the behavior of light sanctions neither our usual nor any other way of rendering space and perspective provides no absolute or independent standard of fidelity.” In Goodman’s view perspective was simply a convention.

Goodman’s work sparked a lively debate with major figures such as Gibson and Gombrich (see below) including a series of notes. For instance, Gombrich (1971) raised questions about how Gibson would have an artist deal with a panoramic alpine view. Gombrich (1979) suggested that if only Gibson had seen some German and Austrian Baroque churches or Bramante’s altar in Santa Maria presso San Satiro in Milan he would not have doubted the illusionistic potentials of painting. Goodman (1979) insisted that Gibson had misunderstood his comparisons between verbal and visual images.

Goodman also sparked a series of other commentaries. Wartofsky (1972) expressed Goodman’s idea of languages of art in his own terms, claiming that the choice of perspective as a canon of fidelity “is an historical act, which involves the adoption of and interpretation of Euclidean geometrical optics as a theory of vision; and that this theory of vision is false”343. Wartofsky (1978) went considerably further. Claiming to develop the ideas of Goodman, he also took up ideas of Gibson to arrive at a position that was the inverse of the theory of the constancies (see below p.), arguing that visual space was a result of experience with representation.

Meanwhile, Lycan (1971) drew parallels between Gombrich’s duck-rabbit problem and aspects of Wittgenstein’s philosophy (see below p. 130*). Couzin (1973) made comparisons between Gibson and Goodman. Hester (1976) believed that he could throw light on Goodman’s claims by distinguishing between conventional (something that involves an end to be achieved and the achievement is subject to scientific verification); based on convention and mere convention. Ward (1976) believed that perspective was mainly a convention but nonetheless concluded that (288):

depicted space in perspective pictures can be seen as real without instruction but only to the extent that the information for flatness is reduced enough to be overlooked or to the extent that viewers learn to distinguish between information for depicted depth and information for flatness. Although the ability to perceive pictorial space increases with practice, even very young children, at least in industrialized societies, seem to have little difficulty in perceiving spatially complex illusions in pictures with a high degree of accuracy.
Jones and Hagen (1978) explored “The perceptual constraints on choosing a pictorial station point” found that (196): “young children prefer pictures drawn with considerable perspective convergence when they are situated at the station point for those pictures. This evidence lends support to Gibson’s idea that pictures carry the same kind of information as the scene they represent.” They suggested that experience with paintings where the station point was at least 10 times the size of the pictured object --as Leonardo and Dürer had recommended, might explain why adults found strong convergence unnatural and therefore rejected Rosink’s (1976) claim that geometrical equivalence necessarily leads to perceptual equivalence. Carrier (1980) returned to the debates between Goodman and Gombrich on the question whether perspective is or is not a convention, noting that a convention can be arbitrary or “the result of innate human characteristics and therefore in a sense objective”. These discussions did not tackle the larger questions.

Steer (1989) set out to explore the implications of Gibson’s theories for art history, which led him to attack Bryson’s notion that paintings necessarily have a semantic relationship (105-106):

> The ‘semantics’ and ‘grammar’ of any mode of communication must surely lie within its own realm and in painting they must derive from our visual and kinaesthetic experience.

> As regards the meanings which paintings convey, a similar point be made. Obviously, what a painting means must be affected by how it means it and since its very nature the visual mode is experiential and the linguistic mode didactic the equation of the two can only lead to confusion. Pictures are not in the least like texts and if we loosely say that we ‘read’ them, or write of their ‘semantics’ or ‘grammar’, it is only because no words exist to describe adequately what happens when we look at them. How visual images mean things is the question that most needs exploring and in this exploration new theories of perception are likely to be a vital tool.

**Perspective as an Objective Method**

Among those insisting that perspective is an objective method in the past generation, three figures have played a key role, namely, Gombrich, Gibson and Pirenne. Of these the position of Sir Ernst Gombrich is perhaps the most difficult to characterize and requires some understanding of a tradition to which he was reacting. In 1956 Gombrich gave a series of lectures on *The visible world and the language of art* which were subsequently published (1960) as *Art and illusion*. Here he attacked the notion that we paint what we see because “seeing” was a complex combination of what we recognize and what we remember. His teacher, Emmanuel Loewy, had focussed attention on the latter factor and described the artistic process in terms of creating memory images. Gombrich chose instead to speak of schema or schemata because he wished to make the point that they were not just rooted in memory. They were open to correction and improvement. Connected with this was his famous phrase: “making comes before matching”. Gombrich insisted that this matching process was not simply a case of imitating or copying nature as earlier scholars had assumed. His hypothesis was to reverse the earlier claim of Hanfmann (1957) that (129): “when classical sculptors and
painters discovered the character of Greek narration, they set up a chain reaction which transformed the methods of representing the human body- and indeed more than that”. Hence the Greek revolution in realism was due to a new interplay between story-telling and image making and this change in function caused a change in form.

Some of his explanations were less straightforward. Gombrich described the background of perspective in terms of Greek art but left open the question whether Renaissance perspective was a “discovery or rediscovery” (cf. 1975, 132). By not taking a clear stand on this question he left open the precise definition of what perspective is. Moreover, he referred (1960, 131) to “the tricks of illusionist art, perspective, modeling in light and shade” in Greek art, as if perspective were indeed a convention, while challenging (247) those such as Read who claimed that perspective was not an objective method. Gombrich also explored analogies (239, 361-365) between the language of art and the language of words, which through the subsequent writings of Goodman became associated with relativistic views of perspective.

To complicate matters he used the example of Ames chairs to explain the principles of perspective and to claim (250) “that any number of objects can be constructed that will result in the identical aspect from the peephole” (Sources, pl. 42). Strictly speaking this is true but it applies particularly to cases where a single object or a single room is involved. It is much more unlikely in the case of an entire context. If a wider definition of perspective is taken namely one which refers to the general laws of integrating information from different planes, then there would be no reason to limit oneself to a single viewpoint and one could test the veridity of a view. By citing only the case with one viewpoint and the Ames example, Gombrich made it appear as if the principles of perspective were more fluid than they in fact are.

Gombrich (1965), returned to these themes in an article entitled “Visual discovery through art”. He now explained the artistic process in terms of recall and recognition and as schema plus correction. Gombrich returned to his claim that the purpose of art that led to perspective (21): “was not so much a general desire to imitate nature as a specific demand for the plausible narration of sacred events” and explored the paradox of inverted recognition (25): “not of reality in a painting but of a painting in reality”. He argued that (19) “whatever can be coded in symbols can then be retrieved and recalled with ease” and spoke of perspective as a code. Terms such as symbol, schema and code were also used by Goodman in favour of the relativist camp. However, Gombrich now stated explicitly that code in the sense he meant it was not just a convention or (20): “a fortuitous code that differs from the way we see....A picture painted according to the laws of perspective will generally evoke instant and effortless recognition. It will do so to such an extent that it will in fact restore the feeling of reality including -and this is most important- the constancies”.

To illustrate the constancies Gombrich chose a superb example from Evans’ Introduction to color (1948) showing a photograph with a row of posts in perspective (fig. ) of which the furthest one had been reproduced alongside the nearest to demonstrate how we interpret size in context. In “The Visual Image”, Gombrich (1972) continued to move away from Goodman’s notion of art as a language by establishing further distinctions between verbal and visual images: “We shall see that the visual image is supreme in its
capacity for arousal, that its use for expressive purposes is problematic and that unaided it altogether lacks the possibility of matching the statement function of language”. In response to Goodman’s claim that “perspective provides no absolute or independent standard of fidelity”, Gombrich (1972) proposed a distinction between the “what” and the “how” of representation. He claimed that if perspective cannot tell us how we will see a picture, its occlusion principle provides us with objective means of determining what will be seen. By way of example he correlated information from a photograph with information on a map. Gombrich also returned to the problem of the constancies. While he agreed with Gibson that there were problems in trying to link phenomenal world and picture, he noted that pictures were also part of the phenomenal world and that (141) “if the phenomenal world bends, turns and twists, so surprisingly does the perspective representation”. He suggested three ways in which a perspective picture is stretched or transformed (149):

The first corresponds to the Thouless effect of the constancies and demands that objects that are drawn as tilted will appear slightly more turned to the beholder than they are really represented. The second, which should be based on the same tendency, would demand that the picture itself, frame and all, would appear less foreshortened than it is; and yet the third, which is the most important and the most interesting, is precisely based on the objective and unnoticed transformations in the plane which are due to this foreshortened view.

In an essay in honour of Gibson, Gombrich (1974) considered the problem of the vault of heaven, suggested that there were two distinct purposes in vision: one, the practical context of everyday life; the other involving orientation, where veridical perception is irrelevant and proposed that in looking at the limits of the visual world, man might have become aware of the visual field. This led him to claim that the curvature of the heavens: “does not represent what we see, but what we really do not perceive. It marks the transition from the world of solid objects to the field we scan for orientation. These two distinct modes of perception may thus account for the existence of two warring schools in the theory of perspective”.

Mach visual space geometrical space
Gibson visual field visual world
Gombrich optical world (mirror) physical world, experienced world (map)

Fig. 16. Comparison of basic terms in Mach, Gibson and Gombrich.

In an essay on “Illusion and Art”, Gombrich (1973) returned to the ways in which changes in viewpoint cause shifts in apparent orientation, now showing how the street in Hobbema’s Avenue (London, National Gallery) tends to follow one around (like the eyes of Mona Lisa) as one moves off to the side (pl. 54.1-3) and compared painting with mirrors and maps. These comparisons were a point of departure in his review lecture at the Royal Society, where Gombrich (1975, 122), used slightly different terms than his predecessors (fig. 16):

There is a common-sense distinction between information about some feature of the physical world (such as a building) and its appearance from a given station point and under given conditions. Maps give us selective information about the physical world, pictures, like mirrors, convey to us the appearance of any aspect
of that world as it varies with conditions of light and may therefore be said to give information about the optical world.

Gombrich pointed out that although maps used conventional signs and symbols the use thereof was not arbitrary. He noted that there were links between maps and photographs, that both were based on projection, which derived from perspective. He pursued his earlier claims concerning the objectivity of perspective in terms of occlusion, the what rather than the how, and provided both an example involving a window (pl. 51.1-4) and a model (pl. 51.5). At the same time, Gombrich maintained his earlier view that perspective projections are not reversible, that a perspective projection “does not give us adequate information about the object concerned, since not one but an infinite number of related configurations would result in the same image”. He thus went on to argue (133):

From a logical point of view a perspective representation, therefore, has this in common with a map that it indicates a class of objects, though a class of which only very few members would ever be known in our environment. It is even possible to formulate the problem of illusion caused by perspective representations in this way. We take one specimen of the class -the flat design on the plane in front of us- for another, the solid object over there.

When he considered the question why pictures are so resistant to anamorphosis that they tend to right themselves he again suggested that we tend to read perspective pictures as maps and thus ignore foreshortenings that occur when they are seen from the side because we “see them as they are”. He went on to suggest why appearances, i.e. the sky or distant panoramas from a mountain top, cannot be mapped. In conclusion he argued that linear perspective was more accurate than other methods, while accepting that artists might legitimately choose to explore subjective rather than objective realms of representation, visual experience rather than the physical world. In “Image and code: scope and limits of conventionalism in pictorial representation”, Gombrich (1978) claimed that while meaning does not depend on likeness: “Western art would not have developed the special tricks of naturalism if it had not been found that the incorporation in the image of all the features which serve us in real life for the discovery and testing of meaning enabled the artist to do with fewer and fewer conventions”. A number of these essays were reprinted in Image and the Eye (1982).

When Gombrich (1988) returned to these problems in an article on “Western art and the perception of space”, he claimed that (5) “the whole subject is in the melting pot” and in a crisis. To explain this he insisted on a clear distinction between the science of optics (concerned with the behaviour of light) and the subject of perception (concerned with visual illusions). He cited a number of classical examples of such illusions using trompe l’oeil (6): “to make it clear that they were not necessarily connected with the portrayal of individual motifs in painting. The creation of illusion and the skill of mimesis, the imitation of reality, went to some extent their own separate ways”. Gombrich refused to take a stand on whether the ancients had developed perspective. He claimed that study of geometrical optics led Brunelleschi to bring these hitherto separate strands together when he made his perspective demonstrations in the fifteenth century. He described Alberti’s concept of the window; noted that (8): “Part of its strength is due to the fact that it is capable of empirical verification” and went on to emphasize the window’s (8) “intrinsic
ambiguity. For though it is true that the level squared floor will always project on the window in the way the method predicts, it is also true that the two-dimensional projection can never suffice to tell us that that floor out there was in fact level and composed of squares”. Alberti’s procedure, he stressed (8): “rests on...the assumption that we have prior knowledge of the shapes to be represented.” According to Gombrich, “the infinite multiplicity of interpretations which Alberti’s view through the window permits” raised further questions of psychology.

Gombrich went on to focus on what he called the radical revolution in perceptual psychology introduced by Gibson whereby our eyes register (11) “not stationary stimuli but the flow of information as we move through the world....Seen from this biological point of view, the fact of traditional perspective that, for instance,a rectangle will project on to the retina or onto the window pane as a trapezoid is not wrong but relatively irrelevant.” Indeed, the perspective of a stationary eye, as recorded in a camera “should be regarded as an oddity. Far from telling us how we really see the world, perspective has created a confusion in the mind of psychologists of perception.” In the final section of his essay, Gombrich drew attention to recent developments in computer technology, concluding that they could well lead to a new art form as did scene painting in Greece and Brunelleschi’s experiment in the fifteenth century.

The third and most articulate defender of the objective dimensions of perspective was Maurice Pirenne. B.A.R. Carter (personal communication) reported that soon after the appearance of White’s (1951) article, Pirenne arranged for a dinner in London hosted by Carter and attended by Gombrich, Gregory and White for the purpose of discussing the question of the objectivity of perspective. Carter agreed, Gombrich half agreed, Gregory and White remained unconvinced. Pirenne (1952), in an article entitled “The scientific basis of Leonardo da Vinci’s theory of perspective”, explicitly challenged the views of those who suggested that perspective was merely a convention, namely, Hauck (1879), Panofsky (1927), Bunim (1940), White (1949-1951) and Pope-Hennessey (1950).
Pirenne set out to prove that Renaissance perspective was the only natural system of perspective. “With a high degree of approximation it corresponds to the way we actually see the world around us”. Pirenne pointed out that:

> it cannot be too much emphasized that the picture drawn in perspective does not by any means aim at representing the retinal image or any pattern of nervous stimulation. Its aim is to send to the eye the same distribution of light as that which the object itself would send. It is for this reason that the problem of perspective is one merely of geometrical optics, not of neuro-physiology.

Pirenne’s key point was as simple as it was essential, namely, that linear perspective establishes an objective, geometrical relationship between an object and its image on the picture plane, which holds true whether or not there is an eye at the vanishing point. In this sense perspective is independent of vision. Pirenne (1958) returned to this claim; again in an article (1963) on “Laws of Optics and Freedom of the Artist” and in his major book, *Optics, painting and photography* (1970), where he explored in detail relationships between vision, representation and photography, while attempting to create a new framework for understanding the claims of Luneburg and others concerning spherical perception and representation. Evett and Pirenne (1974), produced “An experimental demonstration of the validity of scientific perspective”, which was intended as a challenge to authors such as Murray and Murray (1968) who (69): “appear..to cast doubt on the adequacy of scientific perspective to give ‘an exact representation of physical reality’”. Pirenne (1975) returned to these questions.

Among those who agreed with Pirenne were Guillot (1975) who argued that artists had not yet explored potentials of relief effects with monocular vision; Ward (1976), who challenged the views of Goodman, and Wartofsky (286-287): “Perspective may be used according to certain conventions but perspective itself is not a convention...Pictures constructed in a uniform perspective provide viewers with as complete a correspondence to the real world as is possible on a 2-dimensional surface”.

7. Recent Research

In the past decades the work of Hubel and Wiesel and their students have greatly expanded our understanding of the visual pathways within the brain. As Livingstone (1988), reported there are three distinct pathways: one dealing with color, a second with high resolution static form perception and a third concerned with movement and stereoscopic depth. (figure 17). She noted that in the lateral geniculate bodies (b in figure 18) the small cells in the parvo carry information about colour contrast and the large cells of the magno system carry information about luminance contrast (80).
Fig. 18. Model of the human eye and location of the three basic aspects of human vision, in Livingstone, 1988, p. 80: From the magno cells information is sent to layer 4b of visual area 1 (c) and then to the thick stripes in visual area 2 (d). There the signals are analysed to give information about motion and depth. Input from the parvo system is sent to the interblobs of visual area 1 and then to the pale stripes in
visual area 2, where it is analysed for information about shape. Input from both the parvo and the magno systems is combined in the blobs, where it is processed for colour and luminance. It then passes to the thin stripes of visual area 2 and from there to visual area 4.

She identified what parts of the brain dealt with static form perception and movement, before these elements were re-integrated in forming a coherent image of the world. One of the fascinating conclusions of this research was that these three elements of vision were interdependent. Livingstone showed, for example, that a change in colour and contrast greatly changed the perspectival effect of spatial drawings such as Escher.

8. Conclusions

It was shown that already in Antiquity there were two fundamentally different approaches to vision: one assuming that images were innate (Plato), the other relying on the experience of the senses (Aristotle). Within this Aristotelian tradition seventeenth century authors argued that there existed no simple correspondence between images on the retina and visual images as we experience them. In so doing they argued that (linear and atmospheric) perspective was irrelevant for vision. Ironically, largely through Descartes, it was the heirs of the Platonic tradition, who explored analogies between camera obscuras and the eye, and reinstated attention to the importance of perspective for the visual process. By the nineteenth century research into the physiology of vision established conclusively that the curvilinear physical shape of images on the retina had no simple one to one correspondence with rectilinear perception of images.

It was shown how this discovery led to a distinction between geometrical space and visual space, which served in turn as a starting point for Gibson’s distinction between visual field and visual world. The development of Gibson’s theories was outlined and their implications for debates on the status of perspective were assessed. It was shown that there were two dominant schools, one arguing that perspective was merely a convention, a second insisting that perspective was objective; that a major problem in these discussions lay in precision concerning which aspects were or were not objective and concluded that perhaps the most important consequence of these debates lay in how it forced art historians, historians of science, psychologists and philosophers to examine each others’ methods.
IV. APPLICATIONS-TECHNICAL

1. Introduction

In addition to its obvious uses in painting and sculpture, perspective has seen a whole range of technical applications including scenography, marquetry, trompe l’œil, quadratura, architecture, gardens and the environment. It is also used in a series of alternative methods ranging from inverted perspective and anamorphosis to cylindrical, spherical, conical and various conical methods. In addition it is used in reconstructions of perspective in paintings. For these purposes a series of instruments and machines have been devised. Each of these will be considered in turn.

2. Scenography

The field of theatre history is so vast that no attempt will be made even to summarize all that has been written in terms of scenography, or specifically the use of perspective and stage scenery. For the purposes of this study it will suffice to refer to the most important standard, general studies and indicate some of the key monographs for different epochs and, in the case of the Renaissance, for different countries.

Zucker (1925), in his *World history of theatre* touched upon the use of perspective. Allardyce Nicoll (1927), in her important *Development of the theatre*, devoted a large section (85-153) to the use of perspective in scenery. Gregor’s (1933), *World history of theatre*, added some new material. Since then two monumental works have set the standard for studies in the field, namely Kindermann’s (1959), *History of European theatre*, in ten volumes and the *Encyclopaedia of Spectacle* (*Enciclopedia dello spettacolo*), of which the main corpus of nine folio volumes (1954), was followed by a supplement (1954), and an index (1968). Both these works contain rich bibliographies.

Antiquity

Serious discussion of perspective in Greek theatre came from attempts to reconcile Vitruvius’ claims (see above p. 35*) with the evidence of extant theatres. Haigh (1889, 1907), touched upon this in his *Attic theatre* when he included a short chapter (170-173) on mechanical arrangements for scenery as did Pickard-Cambridge (1916, pp. 124-125) in his *Theatre of Dionysius at Athens*. Bieber (1920), in an important work which catalogued all the known theatres, touched on the problem and in the English version entitled *History of the Greek and Roman theatre* (1961) also included a chapter on scenery and mechanical devices.

The absence of direct extant evidence led scholars to look for examples elsewhere that might have been based on the lost originals. The wall paintings at Pompeii became a chief source through a seminal article by von Cube (1906) on “The Roman scenae frons in Pompeian wall paintings of the fourth style”. Bieber (1920), broached this problem (76-81) which was developed in the major studies by Curtius (1929) on *Pompeian wall
paintings and Beyen (1938-1939). Meanwhile, Holl (1906), had related scene paintings to “The development of walls with paintings in the Greek church”. Strzygowski (1907), studied the influence of stage architecture on the art of Antioch. Other media were also examined. Strong (1907), broached questions of scene painting and perspective in his *Roman sculpture from Augustus to Constantine* as did Morey (1924), in his *Roman and Christian sculpture*. Aurigemma (1923-1924) examined “Mosaics with scenes of an amphitheatre in a Roman villa at Zliten in Tripolitania”. Séchan (1926) made Studies on Greek tragedy in relation to ceramics. This led to new attempts at synthesis by Flickinger (1926), in his *Greek theater and its drama*, and by Bulle (1928). Doxiades (1937,1972), examined these problems of space in Greek theatre in terms of larger questions in his *Idea of space in Greek architecture*, as did Martiensen (1964). Krause (1985) reviewed these discussions and also included a brief appendix on the graffiti found at the Theatre in Terracina in 1977.

**Middle Ages**

Early classics such as Chambers (1905), *The medieval stage*, merely referred in passing to the role of perspective in this context. Berstl (1919) related concepts of space in philosophy and theology to changes in spatial practice in stage scenery in general without many specific examples. Springer (1924) in *Early Christian art and the Middle Ages* also broached the theme of perspective. Borcherdt’s (1935) *European theatre in the Middle Ages and the Renaissance* contrasted the traditions of the German Passion play and the French Mystery play, examining their different approaches to the use of space. Important methodologically was his reliance on paintings for evidence of theatrical practice.

**Renaissance Italy**

Modern studies of perspective in the history of Italian theatre began with D’Ancona’s (1872) three volume *Sacred representations of the fourteenth, fifteenth and sixteenth centuries*, which served as a basis for D’Ancona’s (1891) classic *Origins of the Italian theatre*. German scholarship introduced a new level of depth to these discussions beginning with an important thesis by Flechsig (1894), on *The decoration of modern stages in Italy* and a monograph by Hammitzsch (1906), on *Modern theatre construction*, provided a useful outline. Essential source material was provided by Solerti’s (1905) *Music, dance and drama at the Medici court from 1600 to 1637*.

Only gradually was it recognized that the development of theatre decoration and painting were interdependent. Two articles by Fischel were seminal in this context. Fischel (1919-1920) focussed on the theatrical machines attributed to Brunelleschi made for the feast of the *Annunciation* (25 March 1438) in San Felice in Piazza near the Palazzo Pitti (pl. 57.1), citing both the descriptions of Abraham, the Bishop of Susdal and Vasari. Fischel claimed that the configuration of angels used in this Florentine theatre were subsequently adapted by Brunelleschi’s student, Michelozzo, in producing the decorations in the upper section of the Portinari chapel in Sant’Eustorgio in Milan (pl. 57.2). Fischel (1935) in a two part article emphasized the interdependence of “Art and the theatre”, noting for instance that Renaissance artists including Jean Fouquet, Hugo van der Goes, Hieronymus Bosch, Brunelleschi, Bramante, Leonardo, Raphael, Rosso, Parmegianino, Buontalenti and Palladio all played a part in the history of the stage, as did later Baroque artists such as Inigo Jones, Bernini, della Bella, Callot, Servandoni, Berain, and...
eighteenth century individuals such as Tiepolo, Gillot, and Watteau. Fischel cited both cases where stage practice helped in understanding otherwise puzzling aspects of spatial disposition in paintings and specific examples (e.g. Fouquet) of manuscript illustrations which helped to visualize stage practice.

This interdependence of art and theatre was further explored in two articles by Mariani “The architectonic concept in scenography of the seventeenth and eighteenth century” (1923) and “Perspective as an illusionistic element in the architecture of the Renaissance” (1924) which were preludes to his Italian scenography (1930); in Van Marle’s (1924), groundbreaking work The development of the Italian schools of painting; Scharf’s (1925), dissertation on the history of stage design from the fifteenth to the seventeenth century; an article by Mortimer (1930), on “Architecture in the Italian pictures” and Ricci’s (1930), Italian scenography.

Schöne (1933), in a seminal dissertation focussed on The development of the perspectival stage from Serlio to Galli-Bibiena according to the perspective treatises. This was the first systematic study of evidence provided by the theoretical literature. An opening chapter examined the early theatrical productions reported by Serlio, Barbaro and Palladio. A second chapter traced the development of a fully three dimensional stage (Reliefbühne) through Danti’s commentary on Vignola, Sirigatti and Accolti; the rise of scientific stage design with Guidobaldo del Monte and Chiaromonti; the transition to depth and altering stages with Sabbatini, Parigi and Furtenbach; and the evolution of wings (Kulissenbühne) through Aleotti, Dubreuil, and Troili, then Pozzo and Ferdinando Galli Bibiena. The practical side of theatre machinery was further explored by Galante-Garrone (1935), in Scenic apparatus of sacred drama in Italy.

Kernodle (1937), in an important thesis, provided a synthesis of research at the time. He outlined the history of architectural backgrounds in the shaping of space in Greek, Hellenistic and Mediæval examples, noting the convention of exterior settings, tracing the development of both architectural screen and side-house through the middle ages. According to Kernodle there was a basic distinction to be made between a frieze form which dealt with time and a perspective form which dealt with space. The former involved multiple eye-points while the latter involved a single eye-point. A second chapter explored various elements in the development of Italian Renaissance theatre: the shift from a nucleus principle to an enclosing principle; from a frieze form to a single eye-point. He noted the significance of living pictures (tableaux vivants) in triumphal entries and pageants; the role of side house and architectural screens and explored the role of basic elements in the illusionistic perspective scene: floor, wings, heavens, back shutter and vanishing point. A third chapter compared theatre practice in London and Paris in terms of conflicts between mediæval and modern conventions. Selected passages from perspective treatises were included in an appendix. A revised version appeared as a book, From Art to theatre (1944). That same year in France, Leclerc (1944), published a monograph on Italian origins of modern theatre architecture. Krautheimer (1948), in a famous article argued that the Baltimore and Urbino panels of ideal cities were effectively demonstrations of the tragic and the comic scene. This was challenged by Sanpaolesi (1949) and subsequently taken up anew by Battisti (1960).
Magagnato’s (1951), article on “The genesis of the Teatro Olimpico” hailed a new attention to the role of individual buildings in this story, an approach which was reflected in Magagnato’s (1954), *Italian theatres of the sixteenth century* and pursued in an important work by Puppi (1963), on the *Olympic theatre at Vicenza*.

Methodologically important, although consciously very speculative at points, was an article by Battisti (1960), on “The visualization of classical scenes in humanistic comedies”. He noted that the first tragedy which had these characteristics was Gregorio Correr’s *Progne* (c.1428-1429), while the first comedy was Leonardo Bruni’s *Poliscena* (c.1407-1408). He examined Leon Battista Alberti’s *Filodosso* (composed c.1425, performed 1436-1437), offered a hypothetical reconstruction of its scenery and mentioned Frulovisi’s *Corollaria* and *Claudio Duo* (1432), *Peregrinatio* (1437). This led to a reconsideration of the three panels (Baltimore, Berlin and Urbino) of so called idealized cities which he suggested might more fruitfully be seen as visualizations of ancient cities. Battisti noted that Domenico Veneziano’s *Annunciation* (Cambridge, Fitzwilliam) could be seen in the context of stage design and offered a classical precedent.

Eckert (1961), in a dissertation provided a useful survey of the evolution of the perspective scene in Italy. By way of introduction the role of both popular theatre and the revival of classical theatre was noted. His survey of developments in perspective painting and assessment of the significance of the three panels of ideal cities and Bramante’s contribution added little that was new. More useful was his outline of stage practice at Ferrara, Urbino, Rome, Mantua and Florence. Eckert claimed that Serlio brought a synthesis of classical and Renaissance concepts of the theatre and he outlined subsequent developments in mannerist and baroque theatre.


Blumenthal (1966-1967), re-examined the literature on Brunelleschi’s stage machinery for the *Annunciation* and described as a newly identified drawing a folio from the *Zibaldone* of Buonaccorso Ghiberti (Florence, Biblioteca Nazionale, Ms. BR 228, fol.115) which had been noted in Scaglia’s thesis (1960). Neiendam (1969), examined developments in “Renaissance theatre in Rome” between 1480-1530 to show that there was an emphasis on classical comedies played in the original Latin and that there was reason for accepting Vasari’s claim that Baldassare Peruzzi produced the first *trompe l’oeil* scene in relief in connection a play on the Capitoline (1513) and with a production of Cardinal Bibbiena’s *La Calandria* (1514). He also studied the role of humanism in the production of *I Suppositi* (1519) and *La Mandragola* (1520).

A dissertation by Stein (1969), on Italian Renaissance theatre from Brunelleschi to Buontalenti while adding little new material, provided careful chronological lists of
events and developments. Marotti (1974), in a significant work on *Scenic space* analysed the theories of scenography of a number of theorists from the turn of the seventeenth to the end of the eighteenth century: Guidobaldo del Monte (1600), Cigoli (c.1612); Chiaramonti (written c.1614, published 1675), Sabbatini (1638), Troili (1672), Pozzo (1693), Galli Bibiena (1711, 1732), Arnaldi (1762), Vittone (1766), Milizia (1772, 1794), Lamberti (1787) and Riccati (1790). Rutledge (1975), in a speculative dissertation explored the interplay of art and theatre in the late fifteenth and early sixteenth centuries. An appendix contained chronological lists of a number of religious spectacles, pastorals, triumphal entries, classical plays and imitations.

A fundamental contribution was made by an international conference on *Theatre architecture from the Greek era to Palladio*, the acts of which were edited by Cevese (1974, published 1976). This began with articles on the theatre at Sabratha and the Greek theatre (Arias), on the architecture of Roman theatre (Frézouls) and on the shift from Carolingian liturgy to liturgical drama. Most of the essays focussed on themes from the time of Brunelleschi to Palladio. These included many leading scholars including Povoledo, Lotz, Chastel, Cruciani, Frommel, and Puppi. Containing 244 illustrations this remains one of the basic reference works.

An important exhibition focussed on the contributions of Brunelleschi, Vasari, Buontalenti and Parigi to Florentine theatre design. Particularly striking were a series of model reconstructions by Cesare Lisi notably of the device (*ingegno*) by Brunelleschi for San Felice in Pace (c.1430); for the feast of the Annunciation (14 March 1439) in the church of Santa Annunziata (pl. 57.4); a device for the representation of the Ascension in Santa Maria del Carmine that same year (1439, pl. 57.3); Vasari’s apparatus for the Hall of the Five Hundred in the Palazzo Vecchio (1565) and Buontalenti’s apparatus for the Medici Theatre in the Uffizi (1589). A catalogue edited by Fabbri, E. Zorzi and Tofani (1975), reproduced some of these models and provided a wealth of source material.

Another significant exhibition that same year (1975), entitled *Illusion and theatrical practice. Proposals for a reading of scenic space from the Florentine intermezzi to the Venetian comic opera*, was edited by Mancini, Muraro and E. Povoledo.

A fable (*favola*) by Poliziano and an opera by Monteverdi were both entitled *Orpheus*. Pirrotta (1975), used this as a point of departure for a basic study of the role of music in theatre, devoting a very original chapter on temporal perspective and music. A second part of the book by E. Povoledo re-examined the origins of scenography in Italy from the end of the fifteenth century until the time of the Florentine *intermezzi* of 1589. These studies prepared the way for Zorzi’s (1977), *Theatre and the city*, which provided a synthesis of recent research with fundamental new insights. Zorzi focussed on three case studies to trace an evolution from the context of a ducal seat (Ferrara), to a city (Florence) and a republic (Venice). His work brought into focus a complex interplay between the architectural construction of urban spaces and the representation of spatial settings both in art and the theatre. In an appendix Zorzi examined afresh the portico motive in scenography.

Zangheri (1976), discussed Ferdinando Tacca’s role in producing the giant automaton of Atlas used in the gardens behind the Pitti palace for the wedding festivities of 1661. Oechslin (1977), examined the interplay of stage design and architecture and its
importance for what he termed the theatre of invention, drawing attention to the role of unusual viewpoints in the process. A section of the XXIVth Congress of the International committee of art history devoted to Baroque scenography led to a significant collection of 18 essays edited by Schnapper (1979). Pochat (1980), described a series of “Architectural drawings with scenographic motifs from Northern Italy, 1500-1510” now in the Louvre.

Following our earlier practice, in the interests of clarity, monographs on individual scenographers such as Juvarra, Galli-Bibiena and Piranesi have been relegated to the Appendices 4 and 5.

**France**

Early references to the role of perspective in French theatre are found in classics such as Lacroix’s (1868), *Collection of court ballets and masquerades* and Bapst’s (1893), *Essay on the history of the theatre*. In terms of particular plays one of the earliest studies was “The representation of La Calandria at Lyon in 1548” by Solerti (1901). Stuart (1912-1913), explored the problem of “Stage decoration and unity of place in France in the seventeenth century. The theme was pursued in classic works such as Lancaster (1929-1932), *History of French dramatic literature in the seventeenth century*, and Holsboer, (1933) *History of mise en scène in French theatre from 1600 to 1657*. Notwithstanding useful entries in the standard encyclopaedias of theatre cited above (p. 82*), a systematic study of perspective in French theatre has yet to be made.

**Germany**

For Germany a basic study remains Hermann’s (1914) *Studies on the history of German theatre of the Middle Ages and the Renaissance*. Again, a systematic study is lacking.

**England**

Important early studies include Smith (1904), *Elizabethan critical essays*; Chambers (1923), *The Elizabethan stage* and Campbell (1923), *Scenes and machines on the English stage during the Renaissance*. Lawrence (1913), in *The Elizabethan playhouse* had examined problems such as the “The persistance of Elizabethan conventionalisms” and “Proscenium doors: an Elizabethan heritage.” This led to Lawrence’s major work (1927), *The physical conditions of the Elizabethan public playhouse*, in which he claimed that one needed to rid one’s mind of preconceptions (3): “The Elizabethan theatre had no mysteries to conceal behind an ornate proscenium arch and a front curtain, no capacity to drug the senses by means of illusions of paint and canvas or the jugglery of artificial light”. This gave the impression that perspective played no serious role in England. A similar impression is gained if one consults Bentley’s seven volume *Jacobean and Caroline stage* (1941-1968), the index to which contains two references to perspective (I,52; VI, 293-294).

A quite different view was given by Welsford (1927), in his *The court masque* (91): “Some time towards the end of the fifteenth century the picture stage was substituted for the mediaeval system of dispersed decoration and the various houses or mansions were arranged according to the principles of perspective so as to form a single picture”. Welsford went on (174) to note that Ben Jonson’s designs for masque settings at Oxford
showed the influence of the satirical, tragic and comic scenes in Serlio’s *Architecture*. Southern (1935), examined *The staging of eighteenth century designs for scenery* and Bradbrook (1936), analysed *Themes and conventions in Elizabethan tragedy*.

Jackson (1962), in a dissertation on *The perspective landscape scene in the English theatre, 1660-1682*, examined evidence from first editions of plays, contemporary journals and diaries, biographical material and extant paintings of artists who painted theatrical scenery. He noted that in the early years after the Restoration there was a contrast between the architectural quality of continental scenes and a more natural feeling for prospects of the countryside in England, but that after the merger of the two Royal companies in 1682, when the fad for French and Italian opera spread to English theatre, these differences disappeared. Appendices included a study of printed scene directions, theories of scene shifting techniques, catalogues of paintings and a description of Shadwell’s *Psyche*.

Orrell (1983), in an important study demonstrated how topographical views of London by Hollar, Visscher, and Norden, could be related to modern maps in order to determine the actual size of the Globe theatre and other buildings in the area.

**Baroque**

For the baroque period the standard works remain Tintelnot’s (1939), *Baroque theatre and baroque art* and Baur Heinhold’s (1966), *Baroque theatre*, both with rich bibliographies.

**3. Marquetry**

From the outset marquetry or intarsia was closely linked with the rise of perspective (cf. *Sources*, pp. 155-156*), as was noted by Renaissance authors such as Benedetto Dei (c.1470) and Vasari (1558). In Italy it remained of fundamental importance until the early sixteenth century. By the mid sixteenth century it had made a belated appearance in Germany and the Netherlands mainly in secular contexts where it continued a certain importance until the early seventeenth century.

That marquetry had fallen out of fashion by the time when a more critical historiography of art was emerging offers one explanation why there were no major studies on marquetry during the seventeenth, eighteenth or even nineteenth centuries. A second reason relates to general biases within the historiography of art, which favoured attention to so-called high art, notably painting and sculpture, while giving short shrift to the so-called minor or decorative arts. The latter half of the nineteenth century, particularly through the efforts of Semper, Riegl and Ruskin, challenged this tradition and saw the establishment of museums devoted specifically to these decorative arts (*Kunstgewerbe, arts décoratifs*).

<table>
<thead>
<tr>
<th>City</th>
<th>Building</th>
<th>Scholar</th>
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<tr>
<td>Bastie D’Urfé</td>
<td>Chapelle</td>
<td>Raggio (1972)</td>
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<tr>
<td>Bergamo</td>
<td>S.M. Maggiore</td>
<td>Angelini (1968)</td>
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<tr>
<td>Bologna</td>
<td>San Domenico Alce</td>
<td>(1969)</td>
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<tr>
<td>Ferrara</td>
<td>Cattedrale</td>
<td>Venturi (1916)</td>
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<tr>
<td>Genoa</td>
<td>San Lorenzo</td>
<td>Torriti (1955), Armani (1971)</td>
</tr>
<tr>
<td>Gubbio</td>
<td>Studiolo</td>
<td>Comstock (1941), Remington (1941), Clough (1967)</td>
</tr>
<tr>
<td>M.Oliveto M. Abbazia</td>
<td></td>
<td>Brizzi (1989)</td>
</tr>
</tbody>
</table>
Reggio Emilia San Prospero Monducci (1965)
Sansepolcro San Francesco Salmi (1972)
Savona Duomo Varaldo (1894), Torriti (1951) (1952), Armani (1971)
Siena Cattedrale Thornton (1974)
Verona S.M. in Organo Rognini (1978)

Fig. 19. List of cities, churches with marquetry work and authors of studies.


Related to this was another approach which focussed on the evidence provided by a particular church, chapel or monastery (fig. 19). This work, often carried out by local amateurs, admirable both for its detail and its enthusiasm, could not of itself provide more general insights, whether the activities of an artist in Bologna or Urbino represented strictly—an earlier generation might have said merely—local expressions or whether they were recognizably part of larger trends connected with a particular order of the church or other group.

Serra (1934), was one of the first to consider marquetry as a serious expression of Renaissance art. This approach was taken much further by Chastel whose synthetic studies gave a new sense of how the workshop traditions in Italy represented much more than simple local events. Chastel (1957), specifically addressed the question of the significance of marquetry and explored its uses. Corboz (1964-1965), raised deeper questions in this vein. Kreisel (1968), in his standard work on the history of German furniture illustrated a number of important examples of marquetry in the North. Jockusch (1993), in an important dissertation focussed on architectural motifs in Italian marquetry, focussing on the work of Fra Damiano. While some links with real architecture in the form of town views (e.g. Monte Oliveto near Siena) and of ruins were discovered (e.g. the Colosseum, Rome), Jockusch found that most of the marquetry entailed imaginary buildings and cityscapes.

4. Trompe L’Oeil and Illusion

The general theme of Art and illusion has provided the title of at least three books in our century: Pap (1914), Johansen (19**), and Gombrich (1960). Trompe l’oeil has entered into discussions of whether or not the eye sees the natural world in the same way that it sees representations of nature in paintings (see above p. 69*). Other discussions involve the psychology of visual illusions (see below p. 135-137**). Several books have provided illustrations of trompe l’oeil images with little or no analysis. Otrange Mastai (197*), remains of interest.
Fig. 20. A classification of *trompe l’oeil* figures from Kubovy (1986, 68).


Sandström’s (1963), *Levels of unreality*, was one of the few books to explore the deeper problems of trompe l’oeil. In an opening chapter he examined the role of the narrative tradition in art in “conquering the wall”, asking what is a picture and exploring both communication between and content in different spheres of the image. A second chapter focussed on the passage between picture and real space using the Cappella Bufalini (Rome, Santa Maria in Aracoeli) by way of illustration. A third chapter outlined transformations in the concept rooms: differences between an opened and a closed wall,
181

the role of vault decoration and ceiling painting, reflecting on the influence of antiquity. A final chapter used the example of the Sistine Chapel ceiling to explore the structure of objects. As noted earlier (p.66*), Burda (1969) examined types of trompe l’œil used in the Low Countries. Kubovy (1986), in the context of psychological problems of perspective, offered a more general classification of basic types of visual illusion (fig. 20).

5. Ceiling Painting or Quadratura

One of the most dramatic applications of perspective has been in the context of fictive ceiling painting and architecture which, since the late seventeenth century has been termed *quadratura*, presumably in reference to the grid or graticule used both in constructing the quadratura motif and in transferring it to the vault.

One of the first systematic studies in the field was an important dissertation by Kellermann (1924) on *The concept of space in perspectival ceiling painting in Italy*. Following a brief survey of previous literature, Kellermann examined the concept of illusionistic painting, tracing its antecedents in Hellenistic and Mediaeval examples. A third chapter was devoted to fifteenth century examples notably Mantegna, Melozzo and Pinturicchio; a fourth chapter focussed on two fifteenth century examples, Leonardo da Vinci’s *Sala delle Asse* and Michelangelo’s *Sistine Chapel*. A fifth chapter examined Mannerist examples notably followers of Raphael and imitators of Michelangelo. Chapters followed on early baroque painters including Correggio, Parmigianino, Titian, Tintoretto and Veronese; and on painters from the Academies, the Carracci, Reni, Domenichino and Tassi. An eighth chapter examined ceiling painting of the high baroque, focussing on three different trends: first the quadratura painters per se (the Alberti brothers, Dentone, Colonna, Mitelli, Alboresi, the Roli brothers, Chiavistelli, Franceschini, Stagi and Romei); second a painterly trend (Lanfranco, Cortona, Giordano, Baciccio, and Odazzi), and third, an architectonic-painterly trend (Ansaldo, Benso, Pozzo, the Melani brothers and Fumiani). A ninth chapter examined late baroque ceiling painters (Solimena, Conca, Schor, Coli, Gherardi, Rossi, Piazetta, Amigoni and Tiepolo). A final chapter explored the implications for architecture of these perspectival ceiling paintings. One of Kellermann’s enduring contributions was to focus on the role of brothers (e.g. Alberti, Roli, Melani) and whole families, (e.g. the Carracci, the Colonna) in passing down these techniques from one generation to the next. His thesis included 55 plates.

An important article by De' Maffei (Italian 1958, English 1965) began with brief discussions of illusionistic perspective, architectural perspective (quadratura) painters and illusionistic painting in religious buildings. She examined the fifteenth century Italian forerunners of illusionism (Masaccio, Niccolo da Tolentino, Piero della Francesca, Mantegna, Melozzo da Forli); considered briefly perspectivists in sixteenth century Rome (Michelangelo, Raphael, Baldassare Peruzzi); illusionistic areal perspective in Emilia (Correggio, Guadenzio Ferrari, Benvenuto Tisi); mannerist perspectivists (Giulio Romano, Girolamo Genga, Bronzino, Vasari). Sections followed on the new theorists (Barbaro, Scamozzi, Vignola); Venetian perspectivists (Palladio, Zelotti and Fasolo--their assistants Antonio Vicentino, Girolamo del Pisano, Alessandro and Giambattista Maganza--, Veronese-- his followers Domenico Riccio, paolo Farinato, Battista Angelo
del Moro and Bernardino India--; Lattanzio Gambara...; Bolognese perspectivists in Rome (Ottavio Mascherino, Tommaso Laureti, Lorenzo Sabatini, Egnazio Danti, Pellegrino Tebaldi, Agostino Tassi); illusionistic figure painting (Carracci brothers, Gaulli, Pozzo); the Bolognese school of quadratura painting (Curta, Colonna, Mitelli, Piola, Haffner, de' Ferrari, Giordano, Solimena, Ricci, Fumiani, Piazzetta, Crozotto, Mingozzi); Italian perspectivists active in German Regions (Pozzo, Pellegrini, Amigoni, Appiani, Tiepolo) and German perspectivists (Schor, Waldmann, Asam brothers, Rottmayr, Gran, Altomonte, Scheffler brothers, Zimmermann, Wink, Holzer, Mgges, Göz, Günther, Zick, Troger...Maulbertsch). Particularly useful was the way in which the author outlined how this Italian approach gradually spread throughout many parts of Europe.

Unaware of this work, Horstmann (1968), in a dissertation identified eight steps in The development of perspectival ceiling painting, beginning with the first attempts at a view from below prior to the use of a perspectival background (Masaccio, Saint Paul, Santa Maria del Carmine). A second stage involved the construction of a fictive architecture seen from below (Masaccio, Trinity, Santa Maria Novella). A third stage used foreshortening of the figure in the case of painted statues (Uccello, John Hawkwood or Giovanni Acuto, first version, Santa Maria Novella). A fourth stage entailed bringing together of individual figures in a view from below within a decorative system, (Uccello, Hour dial and giants or Castagno's Famous men). A fifth stage introduced many figured narrative scenes seen from below (Donatello's Handing over of the keys and Miracle of the donkey). A sixth stage adapted methods from relief within the context of painting proper. In a seventh stage there was an increase in the field of depth and perfect foreshortening of figures (Mantegna, Saint Jacob on the way to the courts). Finally an eighth stage introduced an illusionistic extension of the entire space off to the side with the help of perspective from below (Angelo del Maccagnino, Studio of Belfiore). Part two of the thesis surveyed early examples of perspectival ceiling painting, notably, Foppa, Mantegna, Leonardo, Sodoma, Michelangelo, Raphael and Correggio.

Sjöstrom (1972, English, 1978), returned to this theme in Quadratura. Studies in Italian ceiling painting which was important because it classified these ceilings in terms of nine types (fig. 21, pl. 65-66). While focussed on Italy, Sjöstrom added an excursus on French treatises and cited examples of Domenico Francia in the Royal Castle, Stockholm.

Czymmek (1981), in a published dissertation also explored the typology, sources, significance and development of ceiling painting in Italy and Germany until c.1700. Knall-Brskovsky (1984), in a significant dissertation focussed on the use of quadratura in the Austrian baroque.

1. Fictive architecture, closed
2. Fictive architecture, open upwards and to the sides
3. Fictive architecture with central opening
4. Fictive architecture with central painting surrounded by niches, reliefs and busts
5. Sieve ceiling (surface bound structure perforated by four openings)
6. Cross between surface bound structure with central fictive cupola and corner openings with barriers
7. Raised fictive ceiling with hovering figure enclosed
8. Raised fictive ceiling with fictive walls angled inwards
9. Fictive barrier

Figure 21. Classification of nine types of ceiling painting by Sjöström (1978).

6. Architecture

Giedion (1941), in *Space, time and architecture*, was convinced that a society without a clear perception of its relation to the past would proceed aimlessly and myopically. A knowledge of history was therefore “prerequisite for the appearance of a new and self-confident tradition”. Giedion’s view of that tradition was sharp and clear cut. He saw Florence as the workshop of the modern spirit. “In the Renaissance the longest step forward was taken during the ten years between 1420 and 1430. Perspective, in his view (31):

came as a complete revolution, involving an extreme and violent break with the medieval conception of space and with the flat, floating arrangements which were its artistic expression. With the invention of perspective the modern notion of individualism found its artistic counterpart. Every element in a perspective representation is related to the unique point of view of the individual spectator.

Giedion argued that there was no single inventor of perspective, that it was the expression of an epoch, “used at once with complete confidence and sureness”, combining both art and science and cited Brunelleschi as an initiator. Masaccio’s *Trinity* was of particular importance because its longitudinal barrel vault “was to prove the great solution to the vaulting problem that confronted architects of the full Renaissance and baroque periods.” He saw the first concrete architectural expressions of this form in the interior of Alberti’s San Andrea at Mantua (1472) and Bramante’s illusionistic choir in Santa Maria presso San Satiro in Milan (1479-1514) and the nave of Saint Peter’s in Rome (1607-1617) as (36) “its culminating point”. Giedion claimed that in the Renaissance (42) the exaltation of the individual ego began to superecede the old team spirit of the Middle Ages and paved the way for the absolutism of the seventeenth century”.

This explanation, which quite overlooked the enormous growth of the guild tradition in the Renaissance, the growth of banks and corporate structures, allowed him to focus on one strand as the only consequence of perspective (43):

The Renaissance was hypnotized by one city type which for a century and a half - from Filarete to Scamozzi - was impressed upon all utopian schemes: this is the star shaped city. From a symmetrical fortified polygon, radial streets lead to a main center. This is the basic diagram. The central area is either left open, as in the completed Palmanova (1593), or contains a central tower - a central observation post- from which the streets are seen in shortened perspective.

Although he stated explicitly that one should not judge Renaissance town planning simply in terms of ideal cities, Giedion claimed that no artists of the time (55) “left us a plan for a new type of town” and that what was new in their civic design had to be sought in mastery of a town’s constituent elements, e.g. palaces with bold walls, streets which were agglomerations of heterogeneous buildings and open stairways. All this he contrasted to the baroque (54):
Baroque perspective on the other hand, was based on a limitless field of vision. Hence typical towns of the late Baroque period, such as Versailles (second half of the seventeenth century) and Karlsruhe (about a hundred years later) have nothing to do with the star shaped plan. The palace of the ruler stands boldly between town and country, dominating -at least in the optical sense- limitless space.

In Giedion’s view, perspective continued as a habit for four centuries. Perspective was misused in the nineteenth century, which also saw the rise of a non-Euclidean geometry employing more than three dimensions. This led to a “self conscious enlargement of our ways of perceiving space”, which culminated in cubism around 1910 in Paris (436):

Cubism breaks with Renaissance perspective. It views objects relatively: that is from several points of view, no one of which has exclusive authority. And in so dissecting objects it sees them simultaneously from all sides -from above and below, from inside and outside. It goes around and into its objects. Thus to the three dimensions of the Renaissance it adds a fourth one - time.... The advancing and retreating planes of cubism, interpenetrating, hovering, often transparent, without anything to fix them in realistic position, are in fundamental contrast to the lines of perspective, which converge to a single focal point.

According to Giedion, perspective was entirely abandoned after 1910 (cf. below pp. 156-160**). His work was immensely successful going through at least five editions (and sixteen printings by 1966).

A considerably more complex approach was outlined in an important dissertation by Lombaerde (1982). Where Giedion was content to identify two stages in perspectival space (Renaissance and Baroque), Lombaerde outlined six stages which he related to corresponding examples of town planning. He argued that the advent of linear perspective in the fifteenth century made possible its application to the physical scale of the town and specifically in terms of public buildings. By way of illustration he used Pienza. Mannerism he claimed changed this approach by putting emphasis on values of significance thus enriching architecture with new values. By way of example he focussed on the town of Montaigue (Belgium). The Cartesian concept of space brought further changes, focussing new attention on the spaces between buildings namely, streets, the square, garden and park as shown by the town of Richelieu.

The turn of the eighteenth century saw another change whereby space was seen as an assemblage of visible signs. The distinctions between primary and secondary quantities as formulated by Locke and Berkeley meant that links between visible characteristics and those based on sensory perception became a function of learning. According to Lombaerde, Henry Hoare’s garden at Stourhead reflected these trends which were short lived and soon led to two divergent positions: one, based on associationist theories of perception as outlined by Helmholtz in optics and Herman Maertens in town planning; the other, a notion of social utopia as formulated by language analysis which led to drafting becoming an independent system of representation. Lombaerde claimed that the end of the nineteenth century introduced a more aesthetic and psychological approach whereby the panoramic picture and the bird’s eye view became preferential positions of perception which led to garden-districts.
According to Lombaerde the two diverging tendencies continued in the twentieth century. The perceptual tradition showed less and less interest in distinguishing between idea, perception and interpretation. Kevin Lynch’s five organization patterns underlying inhabitants’ understanding of town-settings was cited as an example. The second tendency, mainly through drafting, distinguished notions of space from those of the designing process. Influenced by structuralism and semiotics this gave rise to three further trends (5): “a semantic spatial interpretation closely linked to various cultures; a more grammatical and syntactic tendency which distinguishes sharply between form and meaning and a more pragmatic approach which stresses the role of the subject in the design making process”. Lombaerde concluded with an examination of how proposals concerning various categories (e.g. conception, representation, memory, action, perception etc.) affected both the visual perception theory and the semiotics of the built environment.

Meanwhile, the school of architecture at Cambridge (England) developed an approach which emphasized mapping whereby perspective was reduced to being but one of a series of alternatives as was noted elsewhere (Sources, pp.136-139) in our discussion of the classic work in this context, March and Steadman’s (1971), Geometry of the environment. A similar trend was reflected in the Architecture of form edited by March (1976), which contained fourteen contributions on a quantitative approach to architectural design, three of which dealt with perspectival themes. Derbyshire (74-93), in “Geometric representation of outline design”, outlined a shorthand version of representation which recorded a sequence of cross sections and listed objects in terms of their vertices. Hawkes and Stibbs (116-158), described in some detail work being done at Cambridge on “Computer description of built forms” mainly in terms of parallel perspective. Forrest (159-184), discussed “Transformations and matrices in modern descriptive geometry”. He noted that “for the purposes of visualisation, graphical information has to be transformed so as to provide a particular view” and suggested that transformations perform three basic functions (160):

i. relating users’ coordinate systems to display, plotter, or computer model coordinate systems;
ii. orientation of the object(s) with respect to the selected coordinate system e.g. by rotation and translation to obtain a particular view.
iii. various types of projection and distortion such as perspective, isometric projection, stereo etc.

Transformations in the third category are used mainly to aid the visualisation of objects.

There are other visualisation techniques which are worth discussing, such as dynamic display, selective display, hidden line removal, intensity modulation and shading, which are not transformations in the conventional sense.

In this interpretation perspective emerged as a subset of mathematical transformations. A more radical approach was developed by Hillier and Hanson (1984). Architecture, they claimed, was “usually discussed in terms of what buildings look like from the outside.
But how buildings and towns work has much more to do with how they create and arrange space”. Traditional approaches had tried to link (26):

a material realm of physical space without social content in itself and an abstract realm of social relations and institutions, without a spatial dimension....To remedy this, two problems of description must be solved. Society must be described in terms of its intrinsic spatiality; space must be described in terms of its intrinsic sociality.

With respect to the history of architecture, Corboz (1978), made an important contribution in his Militant painting and revolutionary architecture, which began by showing that Boullée’s supposedly revolutionary architecture at the time of the French revolution was linked with the paintings of Hubert Robert through the theme of the (perspectival) tunnel. Corboz found that archeological ruins of ancient buildings constituted only one aspect of Robert’s sources. He noted that views described by Robert as being drawn from life (dal vero) were often caprices; that the interplay of real and imaginary was much more complex than usually assumed. He traced these developments to neo-classical theories of architecture of Cordemoy and Laugier, showing how the perspectival tunnel view was applied to vegetative variants of ruins, to canals, to covered arboreal versions. Corboz noted that Robert endowed ruins with a new positive function that emphasized the spectacle of disaster, and even extended to visualizing future ruins.

Methodologically Corboz insisted on a simple but fundamental idea, that painting was an important source for architects in designing new buildings, a theme which he pursued in his seminal monograph on Canaletto (1985).

7. Gardens and the Environment

As was noted elsewhere (Sources, pp. 170-182*) comments concerning the use of perspective in gardens can be traced back to the sixteenth century. A passage from Dezallier d’Argenville (1739) suggests that by the early eighteenth century this tradition was being called into question:

Perspectives and grottoes are almost no longer in fashion anymore....As for perspectives they serve to hide gabled walls and walls at the end of a path which one cannot go beyond. They are a fine decoration and very surprising in their illusionistic openings. One paints them in oil or in fresco and covers them above with a little roof.

As was shown, the latter eighteenth century saw a revival of these fashions which extended the notion of the view as far as the horizon. Meanwhile, thanks to the influence of Chinese ideas, imported to Europe through travellers such as Sir William Chambers, an alternative approach which occluded views gained favour and became increasingly associated with the English taste. The nineteenth century brought a number of new treatises on various aspects of perspective in gardening.

Even so, serious study of the history of gardens did not begin until the twentieth century. Guiffrey (1913), made a classic study of André Le Nostre, which touched on his use of perspective. However, most of these early studies were primarily collections of illustrations, as was the case with a fundamental survey of Mediaeval gardens by Crips
(1924) which has been reprinted (1966). Studies by Gromort (1922), on Gardens of Italy and Tipping (1925), on English gardens pointed the way to more specialized work focussed on a given country. An important book by Shepherd and Jellicoe (1925), on Italian gardens of the Renaissance, subsequently republished (1986), was among the first to include analytical discussion of perspectival gardens.

Both De Ganay (1949), in his Gardens of France and their decor, and Marie (1949), in his French gardens created in the Renaissance, again broached the problem of perspective in landscape gardening. Rommel (1954), traced the development of the classic French garden in light of new terms in the language, noting that the term perspective came to mean a painting representing gardens and buildings at a distance. Some coffee-table books, such as Great houses of Europe by Sitwell (1961), and Royal gardens by Meyer (1966), have provided useful illustrations (both engravings and photographs) of perspective in gardens. On a more scholarly front, Wimmer (1969), in his History of garden theory provided a useful collection of source material from early treatises. Fleming (1979), in his English gardens provided new examples of perspectival gardens.

Hazlehurst (1980), in his Gardens of illusion, provided an important biography of André Le Nostre, tracing the influence of Salomon de Caus, Jean François Niceron and Simon Vouet on Le Nostre’s understanding of optics and perspective. A significant contribution of Hazlehurst’s study was to convey a sense of how the effects of foreshortening change as one walks through these gardens of the seventeenth century. As such it remains the best single study in the field. Dennerlein (1981), provided some new material in The art of gardening during the regency and rococo in France, as did MacCubbin and Martin (1984), in a collection of essays on British and American gardens in the eighteenth century, but a systematic study of how perspective transformed European and other gardens has yet to be written.

8. Alternative Methods

Treatises on other categories of perspective have been considered elsewhere (Sources, pp. 98-110). Some attempts have been made to revise the methods of linear perspective and provide easier methods Here it will be useful to focus on secondary literature concerning inverted perspective, anamorphosis, cylindrical perspective, spherical perspective and variant methods.

Inverted Perspective

Some Renaissance paintings, such as Dürer’s Adoration of the Trinity (Vienna, Kunsthistorisches Museum, 1511), depict large figures in the upper parts of the picture and small figures in a reduced landscape below. This is exactly the opposite to what the laws of linear perspective predict. Wulff (1907), termed this inverted perspective, related it to a tradition of bird’s eye views, which he claimed originated in old Byzantine art of the fourth century and explained it in terms of Lipps theory of empathy whereby the viewer supposedly imagined themself in the position of the persons represented. Doehlemann (1910), offered another explanation in terms of hierarchic scaling and Hamann (1910), in a review offered further objections.
Inverted perspective is often found in the context of Russian icons and provoked Florenskij (1920), to write a classic article on the subject in which he argued that this phenomenon could not simply be dismissed as a mistake in linear perspective which he claimed was based on six particular assumptions: 1) that space is Euclidean, i.e. isotropic, homogeneous, and infinite; 2) that in the midst of this infinite space there exists an extraordinary, absolutistic point corresponding to the artist’s eye; 3) that this standpoint is monocular; 4) that the viewer is effectively bound to an absolutistic, immovable throne; 5) that the whole world is treated as unmoving and unalterable and 6) that all psycho-physiological processes of sight are ignored. Linear perspective, he concluded was but one of many alternative methods.

Hence far from being a failure to understand the rules, inverted perspective reflected other intentions on the part of artists. Florenskij’s work has only gradually become known in the West through translations into Italian (1983) and German (1989). Meanwhile in Russia one of the members of his group (cf. above p. 54*), Shegin (1970), pursued the question of inverted perspective and became convinced that it was part of a very complex method of representation involving cylindrical and spherical projection planes. Although this study was translated into German (1982), thus far it has had little impact on European and North American scholarship.

Thouless (1933), speculated that the eidetic aspects of Oriental meditation might help explain the use of divergent perspective in Indian art. Grabar (1945), suggested that Plotinus’ *Enneads* held the answer: a notion of inspiration whereby the devout person lost themselves in the persons they represented led to the viewpoint becoming that of the represented rather than that of the representer. Stefanini (1956) challenged this and argued that it emerged instead from a mediaeval Christian spiritual tradition which made the individual soul the point of emanation. Thereby the vanishing point was in the projector, i.e. the artist, rather than on the screen. Gioseffi (1957), sought to explain away inverted perspective at San Vitale in Ravenna as compromises between adjacent subsystems of central perspective (pl. 15.2). Zajac (1961), explored the visual properties of parallel receding lines and concluded that: “with normal conditions of observation, the convergence of the parallel lines belonging to objects below the eye level should be increased in the picture, and those placed above the eye diminished, in comparison with the geometrically drawn projection of objectively parallel lines”.

Koyama (1965), focussed on examples in Japanese art and claimed it should be considered in connection a) with special problems of vision, namely, binocular sight, optical illusion, visual constancy, and shifts of viewpoint; and b) with special effects of expression through deliberate distortion, not least to create delicate plastic effects. Brion-Guerry (1966), took up afresh Grabar’s interpretation to sketch the history of art as a pendulum between two extremes: one illusionistic involving linear perspective, the other Plotinian, involving inverted perspective.

The field of perceptual psychology sparked new interest in the problem. When Gibson (1970), reviewed the symbol-theory of pictorial information (cf. above p. 97*), he argued that “no rule or canon of inverse perspective could possibly be systematic”, while suspecting that this technique “was quite unintentional and that the explanation is not simple”. In reply, Goodman (1971), insisted that inverted or reverse perspective could be
systematically applied and that, when this method was used with a box seen on end, it actually conveyed more information than linear perspective. Couzin (1973), reassessed these opposing views of Gibson and Goodman, claiming that there were systematic ways of depicting spatially limited objects in inverted perspective but not unlimited spaces, whence there were no landscapes using this method. He was convinced however that problems of inverted perspective were superfluous to Gibson’s theory of information, the real dilemmas of which lay in their conflation of questions of fidelity and depiction.

Almgren (1971), in a carefully documented dissertation examined the phenomenon of inverted perspective in the context of children’s drawings and identified six reasons: through changes in aspect of cubic forms; lack of space; the aim to avoid hidden surfaces; as a result of binocular observation; a quest for symmetrically divisible motifs and as a result of not entirely controlled arm, hand and finger movements.

Having reviewed earlier interpretations of Wulff and Gioseffi, Arnheim (1972), argued that inverted perspective was best explained as a method of enhancing two basic objectives of picture making, namely visual display and expression. He noted that “the wish to combine frontality with a display of the side-faces favors the use of divergent shapes” in both painting and architecture. In modern art inverted perspective serves “to display relevant aspects of three-dimensional objects in the picture plane”; it fits in with a general trend to reduce or even eliminate the hollow space behind the window of the frame; helps add an aggressive dimension to painting while convergent lines are mainly passive and feminine; and contributes to the total compositional scheme of a painting.

Zupnick (1976), believed that the philosophical roots for reversed-perspective went back to Euclid’s *Optics*. Euclid claimed that the eye emitted rays of sight that diverged as they moved from the eye. According to Zupnick artists used this as a basis for “projecting an image on the pictorial surface using their own point of sight...as the point from whence the divergent rays were emitted.” Rauschenbach (1980), in a Russian book claimed that inverted perspective reflected principles of visual perception. In a subsequent English article, Rauschenbach (1983), used the phenomenon of size constancy to claim that the eye sees nearby objects in parallel and inverted perspective and related this to Luneburg’s (1947), experiments. According to this account inverted perspective corresponded to how the eye sees.

**Anamorphosis**

The phenomenon of anamorphosis, also known as trick perspective or curious perspective, seems first to have caught the attention of authors of literature such as Shakespeare in the early seventeenth century as Gilman (1978) has shown (see below p. 114*). By the late seventeenth century philosophers such as Leibniz (see p. 124*) referred to anamorphosis in their works. Even so it was not until the early twentieth century before scholarly interest in the history of the subject emerged. Böttiger (1910), in his monumental analysis of Gustaf Adolf’s art cabinet (*Kunstschrank*) in Uppsala noted that the anamorphic images therein were based on Püschel, Maglioli and Merian. Röttinger (1925), identified two anamorphic woodcuts as the work of Erhard Schön, which prompted Weixlgärtnert (1926) to explore their context; relating them to the Renaissance tradition of perspectival foreshortening as well as other anamorphic images: Holbein’s *Ambassadors* and Parmigianino’s *Self-portrait*. 
Baltrusaitis (1955), made the first serious and only systematic study of anamorphosis, which went through different editions (1969, 1984) and translations (English 1977). He related anamorphosis to the tradition of optical adjustments and scenography; provided a wealth of anamorphic examples, some in paintings or woodcuts, others in treatises. Baltrusaitis traced the spread of these techniques from early German examples in the sixteenth century through the seventeenth century when they became an element in debates first of Dubreuil with Desargues and Bosse; then of Bosse and the Academy and were linked with the Jesuit encyclopaedic tradition (Kircher, Bettini, Schott). Further chapters offered eighteenth and nineteenth century examples; a series involving cylindrical mirrors, plus Chinese adaptations. The 1984 edition added a chapter on twentieth century examples. All this was supported by detailed footnotes and justly remains the standard work on the subject.

Michel (1961), introduced the surrealist comments of Jean Cocteau concerning a cylindrical anamorphosis of a Crucifixion by Rubens. Without any reference to earlier work, Docci and Janniccarri (1963), wrote a brief history which essentially rearranged material analysed earlier by Baltrusaitis. Samuel (1963), doubted that Holbein’s Ambassadors should be seen from the side and suggested instead that it was was intended to be seen from in front using a correcting lens which diminished the size of the image in the longer meridian. Naitza (1970), acknowledged the documentary contribution of Baltrusaitis but claimed that one needed to reconsider the history of anamorphosis. If viewed purely technically, anamorphosis was reduced to a particular case of perspectival virtuosity, as a series of marginal events. In fact, he argued, anamorphosis challenged the legitimacy of traditional perspectival methods. Naitza argued that clear distinctions needed to be made between superficial examples such as Schön’s woodcuts and complex masterpieces such as Holbein’s Ambassadors. To understand seventeenth century examples Naitza suggested that Wölfflin’s concept of open and closed paintings could be extended such that anamorphic experiments were seen as explorations of open space. He noted how science played an essential role in these later works; as did a combination of technique and ideology which led these methods to become part of the Jesuits’ didactic enterprises. Naitza essentially repeated these ideas in a later article (1980).

Holländer (1972), drew attention to four anamorphic paintings by Niceron (Rome, Palazzo Corsini) not mentioned by Baltrusaitis. A consideration of their artistic and scientific context led to comparisons between Niceron’s treatise and the work of his contemporary Descartes. Leeman, Elffers, Schuyl (1976), produced a popular exhibition (Rotterdam, Brussels, Baden-Baden and Paris) based almost entirely on Baltrusaitis’ work. Reviews by Schwartz (1976), and Marmori (1976), and the accompanying Dutch and French catalogues acknowledged this in passing. An American edition of the catalogue “forgot” to mention Baltrusaitis entirely and was removed from circulation. One of the viewers of the exhibition was inspired to reflect more deeply on the problems involved.

Margolin (1977), related anamorphosis in art to allegory in literature: both were open to multiple readings. He noted how some of the anamorphic examples were sexual and scatological; others political, philosophical, mysterious, while some were comical in mood. Margolin suggested that all involved a combination of, rather than an opposition between mathematics and magic, as the sub-title of Baltrusaitis’ book had implied.
Masters (1977), a student of Battisti, produced computer programs for basic anamorphic methods. Schickman (1977), drawing on the work of Guillen and others (see p. 114*), interpreted some of Shakespeare’s images in terms of anamorphosis; related these to paintings and speculated on their meaning, concerning which Turner (1977), raised further questions. Lacan (1980), in an interview with Wahl discussed the meaning of Holbein’s *Ambassadors* in terms of a conflict between eye and gaze: “This picture is simply what any picture is, a trap for the gaze. In any picture, it is precisely in seeking the gaze in each of its points that you will see it disappear”. Veltman (1986) noted that anamorphic effects were often produced by the application of linear perspective under special conditions, e.g. when an object is very close to the picture plane. Hence instead of seeing anamorphosis in opposition to perspective one could view both as expressions of a single phenomenon.

**Cylindrical Perspective**

Linear perspective entails a basic paradox. Its inverse size-distance law applies only to the distance of objects from the picture plane. Thus a long row of houses because they are all in a plane that is equidistant from the picture plane will all remain the same size on the picture plane, even though those off to the side are increasingly far from the eye. Renaissance artists devised various compromise solutions. For instance, Pacioli (1494), produced a rough formula to calculate the necessary diminution. Leonardo, in his quest to devise a plane which was equidistant from the eye appears to have considered a hemicylindrical plane. He drew only a line in the form of a half circle which, if interpreted fully three-dimensionally, would imply a spherical rather than a cylindrical method. Some of his drawings unequivocally show a projection onto a cylindrical ceiling. Pedretti (1963), drew attention to possible links between Leonardo’s work and an instrument for drawing on a cylindrical surface produced by Baldassare Lanci and published by Danti (1583). Maltese (1977-1978, 1980), explored these connections. Veltman (1986, 1986) examined these links in more detail, suggesting that an extant instrument for measuring distance (*distanziometro*, Florence, Museo di storia della scienza) might be identified as Baldassare Lanci’s instrument to produce cylindrical perspective. Relevant passages from Barbaro (1568) and Danti (1583) were cited, translated and discussed. Such cylindrical planes were frequently considered by seventeenth century authors such as Marolois (1614 etc.), or Bosse (1648). In the nineteenth century authors such as Ware (1882) included a chapter on “Cylindrical, curvilinear or panoramic perspective”. This continued in the twentieth century even with authors of standard textbooks such as Abbott (1950,140) who pointed out that:

> There is no need to adhere to a plane surface if a curved one will give an advantage. An obvious advantage in compactness results from the use of a cylindrical sheet as a picture plane, when the perspective of an extensive scene or a long range of buildings has to be recorded....The perspective of tall buildings may be recorded on a cylindrical surface having its axis horizontal. A common example of the method is...where an observer views scenes and figures painted upon a cylindrical surface or wall.

Doesschate (1960), using an example drawn by Dr J. E. Schrek, discussed some of the problems with this method. Historically there has been a certain amount of confusion
between cylindrical and spherical methods of perspective, for which there are two clear reasons. One is terminological, when persons speak of curvilinear perspective and do not distinguish clearly between the two. Another is aesthetic. Notwithstanding the well known curvatures of entasis, artists have used curvatures more for long horizontal stretches than for vertical ones. Hence even when they appeal to a spherical method they frequently correct the curved verticals to arrive at a something very close to a cylindrical projection. One could argue of course that the real problem is a conceptual one. For although many persons think of cylindrical and spherical perspective as different methods, they can in fact be seen as the same method of linear perspective applied to different projection planes. This, for instance, is how Bosse (1648), dealt with the problem (Sources, pl. 58). For the purposes of this survey these traditional categories are maintained.

Spherical Perspective

In Antiquity, Euclid, in his Optics, mentioned apparent curvature of visual space without considering its implications for representation. Renaissance artists such as Leonardo da Vinci, Baldassare Lanci and Daniele Barbaro explored the potentials of cylindrical and spherical projections for both problems of vision and representation, but continued to favour methods of linear perspective. One of the first to challenge this claim was the astronomer Schickhardt (1624) in his Sphere of light:

> I say that all, even the straightest lines, as long as they are not directly in front of the eye against the pupil or go through its axis, necessarily appear somewhat curved. No artist believes this, which is why they paint the sides of a building with straight lines although according to the true laws of optics this is not correct.

Spherical perspective was mentioned by Brook Taylor (1719 etc.), and by Costa (1747). Malton (1779, 95), considered but then dismissed as impracticable images on the surface of a sphere. Malton may have been a source for Turner who occasionally used curvilinear methods in paintings such as Petworth Park (London, Tate Gallery, 1828), and was specifically cited as a source by Herdman (1853), whose Treatise on the curvilinear perspective of nature appears to have been the first work dedicated specifically to the representation of spherical methods. Herdman, however, applied his principles almost solely to horizontal lines and edges. Vertical architectural lines remained straight. He argued that curvature of verticals (100):

> will be found only when lofty elevations are depicted near....In all other instances in which pictures are usually drawn, the vertical attitude is so small as to make any deviation from a straight line either unnecessary or so trifling, as to matter little whether attended to or not.

As Hansen has noted Herdman’s circular perspective was effectively cylindrical rather than spherical. The great French author on perspective, Jules de la Gournerie (1859), considered circular and hyperbolic surfaces but preferred rectilinear solutions that avoided curvilinear images. Viollet-Le-Duc (1863), also broached the problem: “The eye being a portion of a sphere of which the centre is the visual point, the pinnule, all objects
are reproduced on a curved surface”, a passage that was later cited by Borissavlievitch (1951).

Ironically, interest in spherical perspective methods based on analogies with curvature of the retina became more popular in the very generation after the detailed optical experiments of Hering led him to call for a clear distinction between objective retinal space and subjective visual space, and his colleague, Helmholtz insisted that the shape of the retina had no practical effect on the shape of the image (see above p. 90*). In Germany, Scholz (1875), explored these problems in his method of twofold projection which began by projecting an object onto a spherical surface and then projecting the image again by drawing it collinearly. Such problems of perspective were also of particular interest to Guido Hauck, a professor of descriptive geometry in Berlin. One of his earliest articles concerned a general axonometric theory of descriptive geometry (1876). Three years later, Hauck (1879), made a detailed review of modern optics (e.g. Helmholtz, Hering, Wundt, Donders) and developed his own theory of spherical perspective which he believed also accounted for subjective curvatures in Doric architecture (see above p. 37*). He returned to these themes in articles on the relation of mathematics to art (1880), and basic principles of linear perspective (1881, 1882), in which he referred to Scholz (1875). Hauck went on to make contributions to the field of photogrammetry (1873). For over two decades little attention was paid to his work. Then a modernistic art teacher, Stiehler (1906), recommended the use of some of his precepts. He was attacked by a more traditional art teacher, Gehler (1906), in a five part article, who extended his attack to include another teacher (1908), which led to a defence by Grothmann (1909), and led to further comments by both Gehler (1909), and Weinbeer (1910).

No mention was made of these debates by Deininger (1914), who presented a paper to the Austrian Association of Architects claiming that it was only on a spherical surface that one could represent graphically “perspectival dimensions in their proper relation and their correct size”346, and described a device he had patented for these purposes. Paulsdorff (1921) reviewed these ideas favourably as if they were fully original.

In the United States, Ames and Proctor (1921) studied vision in relation to art (see above p. 67*) which led to further studies by Ames, Proctor and Ames (1923), in which the authors reached seven conclusions concerning painting, three of which are relate directly to the theme of spherical perspective (123):

4. A pictorial representation of nature to be technically satisfactory from the artistic point of view should be similar to our subjective impression. It should not attempt to reproduce actuality.
5. Our subjective impressions are, in their general character, similar to the pictures we receive on our retinas while holding one center of focus.
6. A pictorial representation of nature to be technically satisfactory from an artistic point of view should be similar in its general characteristics to the pictures we receive on our retinas while holding one center of focus.

Later artists in the United States were to pursue this theme, with the exception that they believed they had found objective methods of recording retinal images. This paradox of the objectification of the subjective in the context of alternative methods of perspective
has been explored by Veltman (1992). In France, Borissavlievitch (1923, 1925, 1926, 1953) outlined a method of optico-physiological perspective (la perspective optico-physiologique) which he explained: “is not a spherical perspective, and even if it also employs horizontal and vertical circles it is only in considering these as simple perimeters of which the aim is to determine relations between the spatial magnitudes by means of visual angles and not in order to regard the images projected onto these arcs and onto a sphere”.

This was to become a lifetime commitment. Borissavlievitch (1948) wrote a major book on the topic in Serbian, worked for years on a French translation which was not published and instead produced further articles (e.g. 1950, 1955) and another book (1950). He is mentioned here because later critics such as Zanetti (1951) assumed that he had indeed been expounding a method of spherical perspective similar to Hauck.

Meanwhile in Germany architects were continuing to re-invent the wheel. Birker (1923), an architect in Düsseldorf, secured two patents concerning a simple device for spherical projections. Stark (1928), published his Retinal image. Method for the production of the true visual image following the principle of human vision applied to the drawing construction of perspective, which acknowledged only the influence of the philosopher Francé. In a review of Stark’s book, Opitz (1929), was critical of its practicality but again did not question its originality.

In an important dissertation, Hegenwald (1931) reviewed a number of these earlier contributions, notably, Scholtz (1875), Hauck (1879, 1880, 1881), Birker (1923) and Stark (1928); noted that the problem of retinal perspective had excited lively debate a half century earlier, had been forgotten and subsequently revived. He cited Hauck’s view that there were conflicts between collinear and conform solutions and that the position one chose along this spectrum determined the kind of perspective one employed. Hauck and his followers who favoured the conform side had chosen spherical perspective. According to Hegenwald, however, it was impossible to record all the optical impressions of a larger object. One needed to choose a particular viewpoint for which collinearity, and consequently linear perspective was best suited. He thus concluded that linear perspective remained the most rational method which had been developed thus far. Hegenwald’s views were accepted in a dissertation by Eith (1936) on the relationship of perspectival representation to mental (Vorstellungsbild) and visual (Sehbild) image.

In Montreal, Jobin (1932), unaware of these discussions, announced “new theories of artistic perspective and practice” when he wrote Straight line or curved line? a book in which he claimed that the recent development of skyscrapers and airplanes required the application of perspective to vertical as well as horizontal lines, argued that these lines should be curved and maintained that spherical methods of perspective best corresponded to visual experience given the spherical retina (pl. 48.1). In Mexico, Serrano (1934), equally unaware of these discussions, developed his own detailed method of spherical perspective (pl. 50.1). Making no mention of any predecessors, the German engineer Mührle (1941), produced a retinal perspective sheet applicable to aerial views, interiors, photography and engineering which went through several editions (fourth ed. 1949).

Similarly the Italian architect, La Grassa (1947), claimed he had discovered a “new” method for representing the visual field and in the process coined two new terms. One
was optical effect (effettottica) for the “new science which reveals the characteristics of points, lines and angles of the elements of bodies of the entire visual space from a given point of view”. He also coined the term optical perspective (prospettottica) for the representation in a vertical plane of these characteristics identical to the way that they are seen. While La Grassa’s method was praised by both Giorgi (1947), and Boaga (1948), it was challenged by Zanetti (1951), who related it to earlier methods of both Hauck (1879) and Borissavlievitch (1923, 1926), before claiming that linear perspective in fact remained the most efficient method for reproducing both collinear and conform elements of representation. In Germany, Schumacher (1952), produced another sheet for retinal image perspective very reminiscent of Möhrle’s earlier version, again presented as new without acknowledgement.

Not everyone worked in such a vacuum. U. Graf (1941), considered five different kinds of perspective: central perspective as in photography, which was linear and four methods with curvilinear elements, namely, stereographic; Hauck’s perspective; azimuthal and a version which was true to spatial angles (Raumwinkeltreue Perspektive). In a doctoral dissertation, Zeise (1947), reconsidered possible links between optical adjustments and Greek architecture, reviewing the work of Hauck and others who claimed that this involved retinal image perspective. Zeise was a student of the ophthalmologist, Jäger at Kiel, who wrote on these questions himself the following year (1948), and was an advisor of a significant dissertation by L. Graf (Münster, 1949) on Perspective as a problem of physiological optics. L. Graf cited optical writers such as Euclid, Leonardo, Helmholtz and Hering; was aware of alternative methods of representation by Hauck, Stark and U. Graf; considered the relative values of both concave and convex spherical projections and recommended his own version of retinal image perspective intended to compensate for shortcomings in linear perspective which had been noted by architects. Von Gerkan (1954, 1959) listed his objections to retinal perspective both in terms of their practical applications in modern architecture (e.g. Stark, Möhrle) and their value in explaining aesthetic principles of Greek architecture as suggested by Jäger and Zeise. Danielowski (1960), an architect at Weimar influenced by both historical studies and the Viennese school of descriptive geometry developed his own solution which cited the earlier work of Hauck and Borissavlievitch.

In France, the appearance of an important study by Nicod (1962), with an introduction by Bertrand Russell, which claimed to prove that visual space is spherical, served as a point of departure for a brief article by Flocon and Barre (1963) on curvilinear, i.e. spherical perspective. An article by the mathematician Bouligand in conjunction with Flocon and Barre (1964) took these ideas further. The authors claimed that their method of spherical perspective had its roots in Renaissance painting (Fouquet) and cartography (Postel). This served as the basis of a book by Barre and Flocon (1968), for which Bouligand wrote the preface (pl. 47.3-4). Here Fouquet became but one in a list of earlier exponents which included Leonardo da Vinci, Dürer, the author of the Codex Huygens, and practitioners such as Callot, Daguerre, Delaunay and Escher, but left unmentioned the many theoreticians whom we have just considered. A series of seventy eight diagrams illustrated vividly the concepts of spherical perspective and the book gradually became recognized as a basic contribution. Translations into German (1983) and Spanish (1985) followed. Hansen, of hyperbolic perspective fame, produced a translation into English.
(1987) with a valuable foreword. Meanwhile Docci (1975) had described the principles of this method in an Italian article.

**Variant Methods**

There have been a considerable number of variants to these spherical methods. Some have been largely empirical. Dick Termes, for instance, traces his experiments back to 1968 when he was trying to get beyond the limitations of Renaissance perspective:

> After looking at one of my drawings of a six point cube I decided it would be interesting to build a bulging out cube to crawl inside of. I was hoping this cube would look much larger than it was as it would have a built in exaggerated perspective in it. One of my fellow students in this class suggested drawing a cube on a ball would give me the same effect as I wanted in this bulging out cube. I sketched the cube on the sphere after I got back to the studio.

This led to his discovery that the six orientations from the interior of the sphere could be described as six point perspective and thus began a life-long profession of painting on spheres which he called termespheres (pl. 135-138). Termes was initially more interested in practising his art and only began publishing his ideas much later (e.g. 1982, 1990).

By contrast, Vero (1970), was concerned with theoretical written statements and the history of the problem as was the artist-philosopher, Robert Hansen (1973), who had studied the writings of Leonardo da Vinci and began his article on hyperbolic linear perspective with a quote from Schickhardt (1624), cited earlier. Hansen claimed that by attending to the appearance of objects we see curves whenever we look at straight lines, curves which appear as hyperbolas rather than arcs. Accordingly he suggested a circular five point hyperbolic natural perspective to record these appearances.

These descriptions heralded a series of related methods around the world. In Milan, Dan Elias (1973), cited the spherical method of Barre and Flocon as a point of departure for his descriptions of spherical and planispherical perspective, projections less than, equal to and greater than 180 degrees as well as the homosphere. In Rio Di Janiero, the architect Reggini (1974, 1974, 1975), designed a computer programme with curved projection rays which took into account constancy scaling effects such as those studied by Thouless (1931), involving phenomenal regression to a real object. In Madrid, Fuentes Alonso (1975), described his curvilinear method intended to take into account the experience of the eye.

In London, Adams (1976), examined how images projected onto the four sides of a tetrahedron could be used to approximate the complete sphere of vision. Turner (1976), invented his own version of curved perspective. Shaw (1977), in a fine arts thesis described three variant methods which he coined prismism, focalism and strokism. Termes (1980), of termesphere fame, patented a total environment photographic mount and photograph to produce a total picture (fig. 19). This involved coordinated images on a tetrahedron, octahedron, dodecahedron and icosahedron and led to new terms such as tetrahome, tetraperspective, and dodecaperspective. Termes explored the idea that different sides of these regular bodies could be used to record different moments in an event such that the resulting sequence of co-ordinated images represented a personal space-time continuum. He also had the idea of combining two or as many as six of these
spheres together such that one could look simultaneously at all sequences of a room. Similar goals appear to have guided Casas (1983), who first represented a sphere on a flat surface which he termed flat-sphere perspective and then (1984) combined a series of these flattened spheres in a method he termed polar perspective that also integrated different temporal moments.

Moose (1986), an architect in Cincinnati, developed his fisheye perspective in response to a practical problem of viewing the interior of a 93 foot high ziggurat-like atrium he was designing. In New York, the artist Clark (1987), organized an important exhibition of such spherical panoramic views which included the work of Lucien Day, Jacqueline Lima (pl.50.2), Richard McKown, and David Hockney. In Paris, Comar and Blotti (1986, 1987), produced a series of variant methods of perspective for a new exhibition at the Museum of Science and Industry at La Villette.

It is instructive to note that these attempts to record subjective dimensions of visual experience are on the rise although art critics have repeatedly emphasized the logical problems of this approach. For instance, Lalo (1932, 597), pointed out that “the manner of drawing which alters a form or a colour also alters it on the panel and in the same way”, a phrase that was cited verbatim by Blanché (1946). Adams (1962, 36) observed: “Yet a retinal image which a spectator would get from looking at such a picture would be doubly curbed and so fail to match the image produced by the object.” When Friedenwald (1954), suggested that Cézanne’s adjustments were a result of theories of vision to which Luneburg drew attention, Doesschate (1959), challenged this on similar grounds. Heelan (1972), examined Van Gogh’s *Bedroom at Arles* (Amsterdam) in detail and suggested that it was based on a new kind of perception that re-created the world as non-Euclidean visual space (Blumenberg, Luneburg) with constant Gaussian curvature, not just subjective emotions oriented towards a certain vision of being. By contrast Adams (1975), argued that the curvatures in Cézanne and Mondrian invented new pictorial structures in order to reflect a feature of perception. Gombrich (1975), claimed that (126):

> this is a paradox that arises in every case where the artist tries to register his subjective experience regardless of the experience his record will arouse in the beholder. J. J Gibson has referred to the consequences of this aim as the Greco Fallacy, alluding to the naive belief that Greco elongated his figures because his astigmatism distorted them in this way.

9. Reconstructions

Nielsen (1895, 1898 etc.), appears to have been the first to introduce perspectival reconstruction, in the sense of using perspectival lines superimposed on a drawing (pl. 35.1-2) or photograph of a painting. In the early twentieth century, they became much more significant through the work of Kern (1904, 1912), who, in his debate with Doehlemann (1904-1905, 1906, 1912), claimed that these reconstructions provided an important tool in settling questions of chronology in Netherlandish painting (pl. 36.1-2).
Panofsky (1927), in his landmark article used Kern’s reconstructions and made them famous.

Müller (1911), in a significant dissertation, using as a point of departure, the proportion studies of Hoeber, Berlage, Thiersch, Wölfflin and Dehio, reconstructed the geometrical proportions in early German engravings with architectural motifs, notably the Flagellation of Christ by the Master of Calvary (Meister des Kalvarienberges), the large and the small Madonna of Einsiedeln by Master E.S. (1466) and the altar by the Broederlam Brothers showing the Presentation of Christ (1399, Dijon) which, he claimed (25) entailed a distance point or external eyepoint as he called it. Müller re-examined descriptions of perspective by Alberti and Dürer, suggesting that Dürer's interests in proportion probably linked him with the German tradition of master builders; claiming that, for the artists of the Renaissance, perspective is the harmonic arrangement of sizes in space. By implication the seeming discrepancies between German and Italian art, were partly a reflection of different approaches to proportion.

Beginning in the 1920’s, scholars such as Curtius (1929, pl. 34), Little (1937), Kern (1938), and Beyen (1930), used reconstructions in making claims about whether or not the Ancients were familiar with the principles of linear or curvilinear perspective. Gioseffi (1957), used the reconstruction of perspectival lines to claim that Giotto knew the principles of linear perspective over a century before Brunelleschi’s demonstration (pl. 7).

Battisti (197*), used perspectival reconstructions to show that Lombard artists were active in perspective in the second half of the fifteenth century. This theme was developed by Dalai-Emiliani (197*), who analysed the work of Foppa.

Degl’Innocenti (1975-1976), in a Manual for the perspectival reconstruction of Renaissance paintings with architectural representations, outlined his method, which he applied in particular to Ghiberti’s sculptures on the bronze doors of the Baptistery at Florence. Problematic with this approach was a tendency to reconstruct the space as it would have looked if a correct perspective had been used. While very effective this approach was basically ahistorical. Degl’Innocenti (1977), applied this approach to reconstructions of some episodes from the frescoes (c.1460) from Roccabianca depicting the Life of Griselda which formed part of the exhibition at the Castello Sforzesco (Milan, 1977,), on the occasion of the first world conference on perspective. Degl’Innocenti (1980) developed this approach in his beautiful yet misleading reconstructions of Filippo Lippi’s Stories of the Virgin in the Tondo Bartolini (Pitti Palace, Florence, pl. 41-42) and pursued this method in his reconstructions of Leonardo’s paintings for Pedretti’s (1981) work on Leonardo’s architecture.

Lynch (1982) produced a striking reconstruction of the seemingly irregular polyhedron in Dürer's Melencolia, to show that it was in fact a regular truncated cube. This article helped inspire an imaginative, artistic reconstruction of Melencolia by Hanfeld (1994), which integrated aspects of Rahmann's model of the Potsdamer/Leipziger Platz in Berlin.

Mazzola, Krömker, Hoffmann (1986), produced a reconstruction of Raphael’s School of Athens, which unleashed considerable controversy because the relatively primitive quality of the computer images was felt to undermine the aesthetic subtleties of the
original. That same year, Soddu (1986), in *The non-Euclidean image*, provided a computer generated reconstruction of Uccello’s *Chalice*. In the case of Simone Martini’s *Child attached by the Wolf* (1328), a whole series of alternative reconstructions of the space were provided (64-70). These challenged one to think in new ways about the space involved (pl. 43-44). This principle was repeated in the case of Vincent Van Gogh’s *Bedroom* (72-79), Paul Klee’s *Non-composite in space* (80-83) and Balla’s “*A moment of mine of 4.4.1928 at 10.02 a.m.*” (84-87).

The latter part of the book took objects and displayed these in a series of alternative perspective methods. The first was a mosque in Somalia, beginning with a (88): “verification of the limits of traditional perspective trying to represent in a single perspective drawing, the subject who looks at the space and how it is seen by the subject themself”\(^{348}\). This was then shown in normal perspective, and then various views entailing curved perspective. The second was a school shown first in a regular perspective, then in a curved perspective from a bird’s eye view, at eye level, and from a position at one or two meters from the entrance, in a total perspective traced on a sphere, on a cylinder, in a version of total perspective for practical use, viewed from a position near the patio and from a position inside. The next series returned to the earlier example a mosque in Somalia which was shown in total perspective on a sphere represented in axonometry, in total perspective of a cylindrical type, with an interior view, a simplified view, an anamorphic view and one in curved perspective. A final series various versions of a restored building in Mogadishu. Elkins (1994), has provided a useful survey of the history of reconstruction methods.

10. Instruments and Machines

As noted elsewhere (*Sources*, pp. 117-122), books of instruments emerged as an independent category in the sixteenth century (e.g. Besson, Ramelli). These typically contained some perspectival drawing instruments as did treatises on perspective, particularly in the German tradition. The first of these with a conscious historical stance was Pfintzing (1598), who noted the names and dates of various sixteenth century Nürnberg inventors. Hartnaccius’ (1683), *Mechanical perspective* was another treatise in this tradition. Even so it was not until the late nineteenth century that serious lists of available instruments emerged. The most authoritative of these was Dyck’s (1892), classic *Catalogue of mathematical and matematico-physical models, apparatus and instruments*, the second part of which contained sections on “Geometry. Drawing instruments” (225-243) and “Polyhedra” (246-254). The most popular of these was Ford’s (18**), *Mathematical drawing and measuring Instruments*. Its seventh edition (1900) contained three chapters of interest for our purposes: namely, “Instruments for reducing, enlarging, and copying drawings of considerable size- the pantagraph,-theeidograph, -cymograph” (128-148); “Instruments intended to facilitate the delineation of natural objects, buildings etc., camera lucida, Amici’s camera, optical compasses, perspective sighting instruments” (149-163); “Ruling edges for producing radial or vanishing lines -the centrolinead, -rolling centrolinead, -notes on perspective excentrolinead”.

Von Rohr (1905), in a fundamental article, examined perspectival images and the mechanical aids used to understand them such as the perspectival window, Cardi’s
scenographum catholicum, the camera obscura and camera lucida, Branders’s polymetroscopium, optic machines and show boxes. Part two of his article considered dioramas, cameras, the diaphanoscope, the mono-stereoscope and the Verant. Part three (1905), considered the stereoscope and related instruments such as the alethoscope and graphoscope. After this the first half of the twentieth century saw effectively no further general works in this field, as attention focussed on individual instruments. For instance, Straub’s (1949) History of civil engineering scarcely mentioned the problem.

The second half of the twentieth century saw a revival of interest beginning with Feldhaus’ (1953), History of technical drawing, which contained a section specifically devoted to “Drawing instruments” (91-111) which was far from comprehensive. This was equally true of Nedoluha (1957-1959, 1960), and Gernsheim and Gernsheim’s (1956), examples of optical aids for artists, Higbee’s (1958) “Development of graphical drawing”, Danielowski’s (1962), outline of the art of perspectival drawing, Booker’s (1963) significant History of engineering drawing; Havelka’s (1966), “Outline of the historical development of mechanical perspective constructions”, or Veltman’s (1979), survey of some of the chief perspectival instruments used in the Renaissance, his brief outline (1986), of perspectival windows or Sellenriek’s (1987) work on the compass which raised larger questions of representation. A dissertation by Kuns (1980) was exceptional in its attempt to reflect on philosophical aspects of the problem. More recently Turner’s (1987), Early scientific instruments. Europe 1400 to 1800 and Hambly’s (1988), Drawing instruments 1580-1980, have offered a more thorough view of the field. Crary (1990), presented a controversial interpretation of implications for visual theory of early nineteenth century instruments, which is as ahistorical as it is misleading. Meanwhile, there has been considerable attention to the history of individual instruments, notably the camera obscura, camera lucida, camera, magic lantern, perspective box, pantograph, sector, stereoscope and more recently holography, computer and computer graphics, the four C’s, fractals and virtual reality. Each of these will be considered in turn.

Camera Obscura

While the first allusions to the idea of a camera obscura have been traced back to Aristotle’s Problemata, the first clear descriptions of the camera obscura can be traced back clearly to Alkindi’s Optics in the ninth century. By the eleventh century when Ibn al-Haitham wrote his classic Book of vision (Kitab al-manazir) the camera obscura had acquired a considerable significance and as Saccaro Battisti (1980) has shown these aspects featured in the Italian translation that was used in the west, a theme that has been taken up anew in Salvemini (1990). Through Witelo’s (c.1270), compendium these ideas became more accessible. A Renaissance drawing of a camera obscura by Stefano della Bella has an image of the cathedral of Florence (pl. 9.2). This is all the more interesting because the aperture involved is pyramidally shaped like the aperture that Manetti describes Brunelleschi as having used (pl. 10.1). Leonardo included over 250 references to camera obscuras in his notes as Veltman (1986), showed. Even so these early authors typically reported their methods with little or no historical consciousness. There were some exceptions: Cesariano’s edition of Vitruvius (1521), and a treatise by Ridemannus (1670), which traced its use to Roger Bacon, cited the example of a contemporary instrument maker, Cornelius Drebbel.
Bayle (1686), reported on examples of optical chambers without attention to their history. The Abbé Nollet (1735), reported on his invention as if it was without precedent. Brander (1767, 1775), at the outset of his books on new camera obscuras explicitly stated that he did not wish to describe various types. Algarotti (1769), reflecting on its uses for painting, mentioned earlier artists such as Spagnoletto, and Leonardo da Vinci. Buesch, in his Encyclopaedia of the historical, philosophical and mathematical sciences (1775), and in his Attempt at a mathematics for the use and pleasure of bourgeois life (1802), discussed the camera obscura without reference to its history. Häseler (1779), in a technical study of the camera obscura in connection with magic lanterns and sun microscopes referred only to the theories of Euler.

As noted earlier (p. 55*), the second half of the eighteenth century saw the rise of writings on the history of mathematics, particularly in Paris. There were similar developments in optics, although here London led the way with Smith (1755), and Priestley (1775), who was translated into German by Klügel (1776), and soon followed by continental treatments of Kästner (1780), and M. J. Brisson’s (1781), Commentated dictionary of physics (Dictionnaire raisonné de physique). These works were cited by Gehler (1798-1799), whose article in the Physical dictionary (Physikalisches Wörterbuch), traced the history of the instrument from Porta and Kepler, through Hertel, Doppelmayr, Cheseldon and Klügel.

The nineteenth century brought some new contributions such as Wollaston (1812), “On a periscopic camera obscura and microscope”, and provided only isolated notes on the history of the instrument. Guyangos (1840, 148), in his History of Muhammadan Dynasties, mentioned Ibn Firnas who reported that he had “a certain figure of heaven...in his house, and where the spectators fancied they saw the clouds, the stars and the lightning and listened to the terrific noise of thunder”. W.M.L. (1857-1858), reported on Wooton’s meeting with Kepler during which the camera obscura was used for military purposes. Libri, in his History of mathematical sciences in Italy (1865, note II, 303-314), traced its use to Leonardo da Vinci and focussed on Porta. An important biographical article on the life of William of Saint-Cloud (Guillaume de Saint Cloud) by E. L. (1869), drew attention to his use of a camera obscura during an eclipse of 4 June 1285 (mentioned in Paris, Bibliothèque Nationale, Bib. Imp. n. 7291, Fonds lat. 146v.).

Meanwhile, other evidence of the camera obscura’s use in fourteenth century astronomical observations came to light through a study of Levi ben Gerson by Boncompagni (1863). Ersch and Gruber’s General encyclopaedia of sciences and arts (1889) included an article on Levi ben Gerson (Zweite section, 43er Theil, 295-300) which drew attention to his astronomical and mathematical work without mention of his use of camera obscuras. Further studies by Steinschneider (1890), Curtze (1898), Eneström (1898), explored this evidence which was continued a decade later by Carlbach (1910), and Sarton (1910). Erdmann (1899), gave the best survey thus far noting that its basic principles could be traced back to Aristotle’s Problemata (XV,6).

The first two decades of the twentieth century saw an enormous growth in awareness of the early history. Curtze (1901), reviewed what was known, drawing attention to and citing manuscripts of Levi ben Gerson of 1321 and 1342, Cesariano’s (1521), description of Don Papnucio and Porta (1558,1589). General Waterhouse (1901, 1901), provided
another important summary of what was known on the subject, adding a note on Boyle’s portable camera obscura (1909), and summarizing the latest findings in his article for the eleventh edition of the Encyclopaedia Britannica (1910-1911). Eder’s (1905), Extensive handbook of photography drew attention to Roger Bacon before discussing Leonardo, Cesariano, Porta etc. but was again essentially a summary of well known facts.

Developments in Arabic studies changed the picture dramatically. Wiedemann had been active in the field of Arabic optics with an article (1890) on spherical lenses. Wiedemann (1907), drew attention to Al-Kindi’s use of the camera obscura. Wiedemann (1907), turned to Ibn al-Haitham’s use of the camera obscura in his work on the Shape of shadows. This led to a note (1910), and then two important articles on Ibn al-Haitham’s invention of the camera obscura (1910, 1915). These studies were a starting point for Schulz (1914-1915), who explored Ibn al-Haitham’s theory of the camera obscura and Würschmidt (1915), who reviewed the new findings.

Pauschmann (1922), in a fundamental article reviewed the entire history from Antiquity onwards, with precise references both to sources and to secondary literature and remains the most succinct summary of the evidence. Von Rohr (1925), linked the camera obscura with show boxes. Meanwhile, unaware of these studies, Liesegang (1919), continued to describe Porta as the inventor of the camera obscura. Gliozzi (1932), brought the discussion from Porta back to Leonardo. Court and von Rohr (1935), in a significant article, mentioned camera obscuras in the context of a larger discussion of zograscopes, drawing cameras and show boxes. Schaefer and Naumann (1941), provided a popular historical summary in four pages. Schwarz (1948), gave a similar survey in the context of art and photography.

Duhem (1958), returned to the use of pinhole images in Roger Bacon and Levi ben Gerson, a theme taken up a decade later in three articles by Lindberg. The “Theory of pinhole images from Antiquity to the thirteenth century” (1968), reviewed the statements of Pseudo-Aristotle, Alkindi, Pseudo-Euclid, Roger Bacon, Witelo and Peckham. Lindberg’s “Theory of pinhole images in the fourteenth century” focussed on Henry of Langenstein and Blasius of Parma. His “Reconsideration of Roger Bacon’s theory of pinhole images” (1970), turned to Bacon’s discussion in his On burning mirrors. A significant dissertation by Straker (1971), explored the function of camera obscuras in Kepler’s optical experiments. Wheelock (1973, published 1977), in his dissertation reconsidered debates concerning Vermeer’s use of a camera obscura, using experiments with an original seventeenth century instrument as the basis for his claims. This was important because hardly anyone writing about the instrument has actually experienced its effects. Wheelock (1977), focussed on “Constantijn Huygens and early attitudes towards the camera obscura”. Marek (1971), examined the importance of Kepler’s example in subsequent experiments by Young and Fresnel. A book by Hammond (1981), provided the best general survey of the topic thus far. An unpublished Bibliography of the camera obscura by Fyffe (now London, Science Museum, 1986), was the most comprehensive list to date and gave some indication of the immense literature yet to be examined. Not mentioned by anyone so far was a fascinating demonstration of the dimension of distance (demonstratio dimensionis distantia) in the Textbook (Lehrbuch) by Kepler’s teacher Maestlin (Wolfenbüttel, HAB 48.Noviss.8o, pp. 480-481).
1. Camera obscura  Image of the world captured and evanescent
2. Laterna magica  Projected phantasy as a real experience
3. Show boxes  Trick with magnifying glass and superperspective
4. Photographic camera  Time and fixed image of reality
5. Kodak  Photography for all everywhere
6. Lumière’s cinématographe  Images of the world that move
7. Sunsequent boxes  First stage of audiovisual period.

Fig. 22. Seven stages in the development of optical recording devices according to Ganz (1994).

Ganz (1994), in the *World in a Box*, claimed that the camera obscura was linked with perspective and that both arose from a new commitment to recording reality. Tracing the whole history of the problem from the camera obscura to the latest developments in audiovision, he suggested that there were seven stages to be identified (fig. 22).

With respect to historical dates Ganz relied mainly on Hammond (1981) and other standard sources. However, he was aware of little known publications with respect to the laterna magica (37), and as a member of the oldest photographic firm in Zurich had access to a whole range of all but forgotten instruments connected with the early history of moving pictures, all with exotic names, notably: megaletoscopio (71), phenakistiscope (122, 130), praxinoscope (123, 132), mutoscope (124, 134), Wundertrommel (130), Choreutoskop (130), Daumenkino Kinora (132), and Pinacoscop (135). The final section of his book touched on more recent inventions including infra-red photography (1934), Tri-Unials in England, slide projectors, Polyvision with 56 projectors used at the Lausanne world fair (1964), Imax, Omnimax, LCD projectors and virtual reality.

At least two other instruments were intimately connected in principle to the camera obscura. One was the observation well which has been studied by Sayili (1953). A second was the polar sighting tube discussed by Eisler (19**). Closely related were a series of other instruments: the camera lucida, camera, magic lantern, perspective box and show boxes (q.v.).

**Camera Lucida**

The camera lucida is generally attributed to be an invention of Wollaston (1805). It appears to have developed out of the Claude glass, named after Claude Lorraine. Buesch, in his *Encyclopaedia of the historical, philosophical and mathematical sciences* (1775), and again in his *Attempt at a mathematics for the use and pleasure of bourgeois life* (1802), discussed a camera clara. In the generation following Wollaston’s paper there were studies by Ronalds (1828), and Chevalier (1833). A book by Hammond and Austin (1987), provides the only serious history of this instrument. It mentions links with other drawing devices such as the camera obscura, the camera; other instruments such as microscopes and telescopes and includes a detailed bibliography.

**Camera**

No attempt will be made to review here the enormous literature on photography, almost all of which is in some sense relevant to perspective. By way of introduction the reader is referred to Eder’s classic *History of photography* (1905, English 1945); Gernsheim and
Gernsheim’s (1955), biography of Daguerre, with its history of the diorama and the daguerrotype and Scharf’s (1968), Art and photography. The same Waterhouse who wrote on the history of the camera obscura also produced (1902), “Notes on early tele-dioptric lens-systems and the genesis of telephotography”. An important article by Varnedoe (1980), argued against the conventional wisdom that “the fugitive, contingent and fragmentary qualities of impressionist painting were learned from photography”.

In terms of technical principles, A.T. (1862), used perspective in an important article on “Topo-photography or the applications of photography to the making of topographical plans” as did Laussedat in his fundamental studies (1864,1890,1899,1903), themes pursued in the classic work by the Canadian, Deville (1895, 1899), and in a standard text by Deneux (1932), with a bibliography of the principal works on perspective in relation to photography (i.e. métrophotographie, photographie aérienne and sténopé). Streintz (1892) explored the problem of depth perspective and R.B. (1916), the problem of aerial perspective in photography. The same R.B. (1916, 1918), investigated problems of perspectival distortion in photography. F. (1940), considered the question of perspectival distortions produced by tilted cameras and unusual viewpoints. Grabner (1935), claimed that there was no such thing as false perspective in photography. Traenkle (1942), examined the perspectival requirements of devices used to correct distortions. Meinke (1942), in an article on “Secrets of perspective” offered suggestions how to avoid unwanted distortions. Basic in this context was a dissertation by Weibrecht (19**), On the possibility of perspectival requirements in devices that correct distortions, with an important bibliography (149-155). Burkhardt (1958), provided a formula for correcting distorted images. Bartoli (1975), examined the reliability and limits of images in architectural photographs. An anonymous comment (1980), pursued the question of photographic distortion.

Schiffner (1911), discussed geometrical aspects of photographic perspective. Ponzo (1911), of illusion fame, published an instrument for the plastic vision of photographs. The role of lenses in photographic perspective was examined by Seemann (1912), Beckers (1917), and Klinger (1942). Hansen (1924), and Warstat (1924), discussed the relation of lens size and image frame to perspective. Defossez (1930), discussed differences between photographs and regular objects in terms of perspectival effects. An article by Smith and Gruber (1958), compared apparent depth in photographs viewed from two distances. Smith (1958), explored perception of depth in photographs. A series of articles by Keeling (1973-1975), remains the best technical discussion of perspectival effects in photography.

In terms of aesthetics, Fechner (1912), explored the significance of perspectival effects in photographs. Schirrer (1927), examined photographs of Paris and Prague in order to raise questions of linear and rhythmic perspective. Ziegler (1929), considered perspective and proper viewing of photographs. Sonrel (1937), used photography to demonstrate aspects of Renaissance architectural space in Venice. Reisner (1941), considered photographic space and perspective.
Philosophical questions on the meaning of photography were raised by Barthes (1961), with no discussion of, but with implications for, perspective. W. Kemp has been one of the only scholars to explore practical and philosophical consequences of the interplay of perspective and photography in his *Photo Essays* (1978) and *The beholder’s share* (1983). His three volume anthology of writings on the *Theory of photography* (1980-1983) provided much valuable material.

**Cinema**

Again, no attempt will be made to review here the enormous literature on cinema. Fundamental in this context was Liesegang’s, *Dates and sources for the history of projection and cinematography* (1926). Basic also was Quigley’s (1969), history. A survey of large screen formats was made by Wysotsky (1971), in *Wide screen cinema and stereophonic sound* (cf. panoramas and virtual reality, total environments).

With respect to new optical effects, mention should be made of Casey’s *Chemical Man* (1962) produced for Abbott Laboratories for exhibition in the Chicago Museum of Industry at the 1964-1965 New York World’s Fair. The film was projected in a circular room with the audience sitting around the circumference of the theatre. At the same world’s fair, KLM sponsored *To the Moon and Beyond* (1964, later retitled *Cosmos*), which explored scale in outer and inner space using a spherical screen. *Fantastic Voyage* (1966) played with concepts of scale by recording the voyage of scientists who entered the human bloodstream in order to repair a heart problem. Projection on a 360 degree circular screen was again demonstrated at the Montreal World’s Fair (1967). At the Japan Expo (1970), the Fuji Pavilion sponsored *Tiger Child* by Multiscreen (now IMAX) Corporation. These principles were further developed in their *Voyage to the Outer Planets* (1973) produced for OmniMax theatres.

George Lucas, through his company Industrial Light and Magic, has been a pioneer in using computers to produce new spatial effects. In *Star Wars II* (1977), models and computers were first used to create full scale landscapes. The related series from the initial *Star Trek, The Motion Picture* (1979) to *Generations* (1994), have pursued this use
of models to create a sense of reality, with varying degrees of success. The concept of the holodeck is a particularly felicitous example.

In The Draughtsman’s contract (1983), Peter Greenaway explored the use of perspectival windows in an historical film. In the Abyss (1989), computers using Alias software were used to create the remarkable transparent form that emerged from the water and acquired the face of a person watching it. In Darkman (1991), computer graphics were used to reconstruct a three dimensional image of a face. In Terminator II (1991), the same basic software was used to create the mechanical terminator which recomposed itself into the shape of a policeman even after being melted down. These ideas were taken further in Memoirs of an invisible man (1992). The thrust of these efforts was to create fictive images that are indistinguishable from the real. In Jurassic Park (1993), for instance, Steven Williams produced computer generated dinosaurs that were as lifelike as physical models which had been carefully filmed. True Lies (1994) took this trend one step further again by inserting into a live action film whole episodes which were computer generated, such as the one involving Arnold Schwarzenegger flying a Harrier jet. The following year two films, Born to be Wild (1995) and Congo (1995), both introduced computer generated gorillas into a seemingly realistic setting.

The problem of juxtaposition of different scales of reality has been familiar to literary circles since the time of Rabelais' Gargantua and Pantagruel and universally in the English speaking world through Gulliver's Travels by Swift when the protagonist visits Lilliput. More recently this principle of changing scale while retaining other aspects of reality has become a new domain of computer manipulation. For instance, in the Indian in the Cupboard (1995), a toy Indian magically becomes a live Indian only a few inches tall who can be picked up by the young lad who is the protagonist of the film.

These new technical advances introduce possibilities which are as problematic as they intriguing. One can, for example, replace real with fictive images, which raises questions about whether what we see corresponds to what is actually happened. This theme, implicitly touched upon in Quiz Show (1994), was confronted in In the Line of Fire (1993), where a fictive personage was inserted into actual footage from Bill Clinton's presidential campaign and replaced the original protagonist. Forrest Gump (1994), took this theme further. Here a fictional character played by Tom Hanks was inserted post facto into historical footage such that he appeared to have dealt with presidents of the United States and other important individuals. To an informed viewer today, this has a largely humourous effect. But how would someone a century from now, who did not know all the historical details, and was shown such a sequence out of context, be able to know that this was merely entertaining fiction rather than a true documentary?

Not surprisingly, the new technologies have introduced a new theme that questions the veracity of images. In Rising Sun (1993), a video, which ought, theoretically to have provided conclusive evidence of what happened on the scene, is revealed, after very careful analysis to have been manipulated. In Judge Dredd (1995), a photo which the protagonist had grown up believing that it represented his family is revealed to be in fact a clever composite of various photographs and therefore not at all what it seemed to be. Similarly, in the same film, a video, which seems to prove conclusively that the
protagonist was responsible in the cold blooded murder of a couple, is revealed to have been the product of brilliant editing using a look-alike.

Some themes began as analogue problems and are now finding digital parallels. Magnification effects with photographic images, for instance, were the subject of a famous scene in Antonioni's *Blowup* (1966) and again in *Blade Runner* (1982). A digital equivalent was shown in *Species* (1995). Closely related to this are scenes of magnification effects with satellite images in films such as *Street Fighter* (1995). Here a satellite image of Asia focuses in on Burma and eventually to a building in the ruins of the ancient city of Pagan. Similar scenes occur in *Congo* (1995). In *Under Siege II: Dark Territory* (1995), a view of the earth from space focuses on a beach, and finally concentrates on the anatomical features of a person lying on that beach.

In some cases there has been a fascination with special effects almost as an end in itself. The *Star Wars* (1977) series with their extra-ordinary range of realistic, imaginary creatures were a prelude to this approach. *F/X - Murder by Illusion* (1985) and its sequel *F/X2 - the Deadly Art of Illusion* (1991) were two excellent examples of this fascination with conscious manipulation of illusory space. The *Mask* (1994) took this fascination into the playful realm. *Lord of Illusions* (1995) showed that this theme could equally be adapted to the realm of horror. Pixar produced one of the first computer generated three-dimensional forests in the *Adventures of André and Wally B* (198*) and produced the first fully computerized animations in a series of award winning short films including *Luxo Jr* (1986); *Red's Dream* (1987); *Tin Toy* (1988) and *Knickknack* (1989).

Walt Disney, had traditionally relied on hand drawn animations and emphasized character in individual figures rather than spatial sets. Their Mathematical Applications Group Incorporated (MAGI)-Synthavision and three other special effects groups explored the potentials of computer graphics in *Tron* (1982). With respect to more traditional animated stories, these techniques were incorporated in *The great mouse detective* (1986), which involved an impressive sequence within the clockworks of Big Ben. In *The voyage down under* (1989), computer graphics were used to create dramatic perspectival views of canyon walls in Australia. In *Beauty and the Beast* (1990), computer effects were evident throughout the film but most apparent in the ballroom scene which was achieved using a combination of Alias and Renderman software. *Aladdin* (1993) and the *Lion King* (1994) considerably expanded the repertoire of computer generated scenes and landscapes. *Toy Story* (1995), a first example of the combined efforts of Pixar and Disney, moved digital animation to a new plane of realism.

*Lawnmower Man* (1992) used computer graphics to produce the first cinematic record of a journey into virtual reality (see below p.), a theme taken up anew in *Lawnmower Man II* (1995). In *Disclosure* (1994), this theme of virtual reality was taken up in the form of the so-called corridor, in fact based partly on the interior of Saint Peter's Basilica. More recently, *Johnny Mnemonic* (1995) and *Virtuosity* (1995) and *Hackers* (1995), have offered more elaborate versions of such virtual reality walk-throughs and fly-throughs.

A database of films is now available on the Internet (http://www.msstate.edu/M/title-substring).
Lighting

Dourgnon (1946) made a study of lighting using different perspectives.

Magic lantern

Another of the instruments closely related to the camera obscura was the magic lantern which, as it were, reversed the principles in order to project images out of rather than into a box. Eder (1905, 46-55), dealt briefly with it in connection with the history of photography. Battisti (1960), drew attention to the manuscripts of Giovanni Fontana in this context. Quigley (1969), discussed Kircher’s role in its development. Baillard’s (1979), Luminous magic provided fine illustrations and a significant survey. Gosser (1981), returned to the question of Kircher’s contribution. Even so a serious history of this instrument has yet to be written. An idea of the wealth of material that exists was provided by the Catalogue of the Barnes Collection. Part two. Optical projection. The history of the magic lantern (1970).

Perspective box

The passage published by Gayangos (1840) cited in the section on the camera obscura suggests that the perspective box may have had Arabic precedents. The earliest documented box of this kind appears to have been that constructed by Alberti, to which he alluded in his On painting and which was described in the anonymous Life of Alberti edited by Muratori (1750). In the latter sixteenth century Danti (1583) described the use of perspective boxes in the context of anamorphic drawings. Marolois (1614 etc.), appears to have adopted this idea and suggested the use of boxes with V-shaped or cylindrical backdrops. For a brief period such boxes became the fashion.

View                  Location
Reformed church       Nationalmuseum, Copenhagen
Catholic church       Nationalmuseum, Copenhagen
Interior of a Dutch house National Gallery, London
Large room            Museum of Fine Arts, Detroit
Housefront           Nationalmuseum, Copenhagen
Housefront           Bredius Museum, The Hague

Fig. 24. List of extant perspective boxes from Koslow (1967).

The standard article on six extant boxes (fig. 24) remains Koslow (1967), although Elffers and Schuyt (1975), include useful photographs of some of these. Show boxes (q.v.) were a direct development of this principle. Another box recently found in Anghiari is being restored at the local Institute of art. This box, which appears to be fifteenth century, might well be the oldest extant example.

Panorama

On 17 June 1787, Robert Barker, received a patent for a new invention for which he used a French term: nature at a glance (la nature à coup d’oeil). Sometime between 1792 and 1795, it has been claimed, this came to be known as the panorama although it had other names such as the cyclorama. Scholarly study of the subject began with an anonymous German article entitled “Panoramas. General discussion concerning them and a report of their origins and their spread to Germany” (1800, cf. 1800,1803). Bapst (1891), published a basic Essay on the history of panoramas and dioramas. Buddemeier (1970), explored nineteenth century links between panoramas, dioramas and photography.
Readers are referred to Oettermann (1980), who, in his standard work on the subject, listed and discussed major subsequent literature. Oettermann’s approach was by country describing examples in England, France, Germany, Austria, Switzerland and North America. The following year Fruitema and Zoetmulder (1981), produced an exhibition and catalogue to celebrate the hundredth anniversary of the Mesdag Panorama in the Hague.

Bordini (1984), published the most insightful work thus far on the intellectual context of the panorama. While she devoted some attention to the question of origins, her work focussed on nineteenth century developments, specifically in terms of consequences for the imagination, with chapters on changing relations between imitation and illusion, the Arcadian tradition, links with architecture and urbanism. Particularly important were chapters on the treatment of history as theatre (*lo spettacolo della storia*), the estheticization of war and new relations between time and movement. A valuable appendix included a chronological list of all major panoramas from Barker’s *Edinburgh* (1788), to the anonymous *Battle of Stalingrad* (constructed in Volgograd, 1960). Some more recent examples were included in the appendix by Hyde (1988), to an exhibition catalogue at the Barbican Gallery (London), which focussed on British examples and provided beautiful colour photographs.

**Pantograph**

Some primary literature on the pantograph has been mentioned elsewhere (*Sources*, p. 144). Early authors included famous scientists such as Robert Boyle (pl. 85.1). Rössler (1932), examined Jobst Bürgi’s pantograph in Kassel. The history of pantographs was outlined briefly by Feldhaus (1953), and in slightly greater depth by Havelka (1961). A serious history of the pantograph has yet to be attempted. There are a number of complex instruments in this context which have never been studied systematically (pl. 85-88).

**Sector**

The sector, closely connected with other instruments such as the proportional compass, and the reduction compass, is attributed to have been invented by Galileo Galilei (c. 1596, published 1606), but was known in an earlier form to Leonardo da Vinci (c.1505). Particularly in the French tradition, through authors such as Vaulezard, Bosse, and Huret, this universal measuring device became connected with perspectival problems. Laurent (1987), in his significant study of Lambert, devoted a section (116-127) to its use and connections with perspectival problems.

Schneider (1972), has produced the only serious outline thus far of its history. Drake (1960, 1976,1978), published specialized articles on Galileo’s early work in this field. The links with perspective are being explored by Veltman for a future work on the *Mastery of quantity*.

**Show Boxes**

Like the camera, the magic lantern and the perspective box, show boxes were closely linked with the development of the camera obscura. Von Rohr (1925), was the first to deal with the history of this subject seriously. His work was the starting point for Elsner von Gronow, who published two important articles (1932-1932), which were also
published as a separate booklet with nearly identical material (1932). Both von Rohr and Elsner von Gronow were the starting point for Langen (1933), who provided more material. Court and von Rohr (1935), placed these themes in a larger context. Since then Baillard’s (1979), *Luminous magic* provided further illustrative material.

Strehler (1987), noted that, while there were a number of German terms (*Dioramen, Kulissen-Bilder, Kulissen Theater, Guckkasten-Diorama, Guckkasten-Theater*) and Italian terms (*diorami, teatri per scatole ottiche*), to describe a particular kind of show box with scenes based on the theatre, he preferred to describe it as *Room of enchantments, (La camera dei sortilegi)*, also the title of his study. This slender volume was of particular interest because it provided beautiful colour photographs of a number of these show boxes.

**Stereoscope**

Developed by Wheatstone (1838), partly in response to problems of binocular vision described by Leonardo da Vinci in his *Treatise on Painting*, the stereoscope became one of the most popular viewing devices of the nineteenth century. Pulfrich (1911), outlined its history. Lipton (1982), remains the standard history of this instrument, particularly as it relates to the development of stereoscopic cinema. In the 1980’s there was some work in stereoscopic photography (e.g. Kupka). In the 1990’s there was a trend towards viewing such stereoscopic images on computer screens to provide a simplified version of virtual reality.

**Telescopes**

In the seventeenth century the telescope was frequently referred to as a perspective glass(e). Sonnefeld (1924), and Luxenburg (1927,1927), discussed cases of distortion while looking through telescopes. Larsen (1977), demonstrated that the inverted telescope was used in Dutch seventeenth century landscape art.

**Zograscope**

The zograscope or optical diagonal machine, often also referred to by its French name, *optique*, was discussed by Chaldecott (1953), and mentioned by Hammond (1981).

**Developments since 1950**

**Holography**


**Computers and Computer Graphics**

With respect to computer graphics pioneering work was done in the 1960’s. Green (1961), wrote on figure coherence in the kinetic depth effect. Roberts (1963), described machine perception of three dimensional solids and Roberts (1966), considered homogeneous matrix representation. Haynes (1966), was perhaps the first master’s thesis specifically on *A computer method for perspective drawing*. Loutrel (1967), devoted a thesis specifically to hidden lines in computer drawn polyhedra. The Mathematical Applications Group Inc. (MAGI, 1968) focussed on 3-D simulated graphics. All of these
were cited by Sutherland (1968), in his important article which first outlined the principle of a head mounted display (fig. 31-32).

The earliest standard textbook, Newton and Sproull (1973), included a few seemingly simplistic drawings as examples of computer graphics (fig. 25-30). These are actually more complex than they at first appear. Renaissance perspective set about determining the vanishing points of an object as seen through a stationary window and places that object in a static space. Perspective on a computer screen assumes one space for the context (the basic xyz co-ordinates in fig. 26). This contextual space typically assumes a viewpoint at infinity and thus entails a viewbox that is equivalent to parallel perspective (fig. 30). Within this viewbox it then permits a user to establish a movable viewpoint with adjustable visual angle or aperture, viewing direction and distance. While revolutionary in its implications, this left many unsolved problems. First among these was hidden surface removal which was solved relatively quickly. More difficult were problems of complex surfaces and attendant complications of aliasing. As a result the early images had a non intentional roughness about them (pl. 99.1-6). In the course of the 1970's individuals at the frontiers such as Greenberg produced more polished images which were considerably more effective largely because they focussed on rectilinear planes and provided a sense of context (pl. 100).

It was not until the latter part of the 1970's that computer graphics emerged as an independent domain. An article by Carlbom and Paciorek (1978), outlined some of the new possibilities for art history. Deken (1983), compiled one of the significant early anthologies of images in computer graphics at the popular level. *Computer graphics, principles and practices* by Foley, van Dam, Feiner and Hughes (1990 etc.) replaced Newman and Sproull as the standard text in the field. Their sixth chapter on Viewing in 3D built on the theoretical work of Carlbom (1978) and began with a clear description (229):

> In 3D viewing, we specify a view volume in the world, a projection onto a projection plane, and a viewport on the view surface. Conceptually, objects in the 3D world are clipped against the 3D volume and are then projected. The contents of the projection of the view volume onto the projection plane called the window, are then transformed (mapped) into the viewport for display.

The authors described linear (one, two and three point) perspective and a variety of parallel projections: orthographic (front-elevation, top- or plan-elevation and side elevation), axonometric (particularly isometric) and oblique (notably cavalier and cabinet) projections. They identified three successive planes: a front clipping plane, a view plane and a back clipping plane, which are of equal size in parallel projections and of successively larger sizes in regular perspective. A series of stages in the perspective-viewing pipeline were outlined. They explained how five different co-ordinate systems were integrated in the context of computer graphics: 3D modelling (object) co-ordinates, 3D world co-ordinates, view reference co-ordinates; normalized projection co-ordinates and 2D device co-ordinates.

Fig. 31. Diagrams from Autodesk’s 3-D Studio illustrating the principles of adding and subtracting objects or parts of objects.

Meanwhile, Friedhoff and Benson (1989), provided a good popular introduction to the emerging field of visualization. In the United States, the Association for Computing Machinery (ACM) has a Special Interest Group for Graphics (SIGGRAPH), which has become one of the international standards in the field. At the academic level the National Center for Supercomputing at Urbana-Champaign (Illinois) is the most important single
institution and has produced a series of videos relative to the emerging field of scientific visualization.

Other important centres include the Jet Propulsion Lab (Pasadena), where Fred Blinn produced *Mars the Movie*, and various other pioneering efforts in the realm of graphics; the Massachusetts Institute of Technology (M.I.T., Boston) and the Yorkton Heights Laboratories of I.B.M., where Pickover (1991), has produced significant work. The single leading studio for computer graphics remains Pixar (see above p. 132*). It is frequently overlooked that much of the software for the Jet Propulsion Lab, The U.S. Force and and other serious users of graphics, including Walt Disney comes from the Canadian firm, Alias.

In the field of Computer Aided Design (CAD), Autodesk set a standard at the popular level with products such as AutoCAD, Animator Pro and 3-D Studio. All three of these products employed systematic treatment of the x,y, and z axes and improved greatly on the earliest attempts. Whereas Renaissance perspective typically employed a ground-plan in combination with an elevation, or another combination of two views at right angles to one-another, 3-D studio offered its users four simultaneous views of the object to be drawn (pl. 103.1): a ground plan (top, X/Z), a frontal view (front, X/Y), a side view (left, Z/Y), and a view of the perspectival result (camera01). The sequence of these four views can be altered at will (cf. 103.1 and 3).

3-D Studio also introduced a camera function such that one could obtain the equivalent of a view seen through a series of lenses (fig. 32).

<table>
<thead>
<tr>
<th>Lens Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>15mm.</td>
<td>28mm.</td>
</tr>
<tr>
<td>20mm.</td>
<td>35mm.</td>
</tr>
<tr>
<td>24mm.</td>
<td>50mm.</td>
</tr>
</tbody>
</table>

Fig. 32. Equivalents of lens sizes available in Autodesk’s 3-D Studio.

The mastery of spatial coordinates represents but one aspect of this revolution. 3-D studio also allows systematic joining and separation of objects to produce their intersection and union or the subtraction of one part from another (fig. 31), thus introducing into computer graphics a three D version of the geometrical game (*de ludo geometrico*) made famous by Leonardo in the first decade of the sixteenth century (cf. Veltman, 1986, 1993).

Equally significant has been the development of a whole series of standardized surfaces. These can be varied both in terms of numbers of surfaces and the textures or patterns on these surfaces. For example in creating a sphere-like shape one can choose at will between a 12-, 24- and 60-sided Lsphere (pl. 103), without having to construct each of the sides individually. These alternatives produce spheroid shapes of differing edge clarity and roundness. In the Renaissance, it will be recalled, each of these posed an individual challenge. Similarly, in the Renaissance the combination of a spheroid and a toroid would have posed two drawing challenges, although as we have notedv individuals such as Sirigatti did sometimes combine them on a single page as a demonstration of bravura (Sources, pl. 37). In 3-D Studio, no bravura is required. The shapes can simply be chosen, positioned (pl. 103.3), the faces to be tesselated identified ere one arrives at a fully textured spheroid and toroid (pl. 103.4). A whole series of different textures can be chosen. The most elementary of these is the wire frame. Benson (1990), illustrated seven
other variants: hidden surface removed, Lambert shading, Gouraud shading, Phong shading, texture mapping, bump mapping and transparency rendering (pl. 101-102).

More recently, Autodesk has introduced a series of plug-ins such as Spherify, a procedural modeling tool that converts any object into a sphere; Stretch, which fits any object within a deformable “scaling” box, and Hedra2, which allows creation of all the major polyhedra and morphing within their hedral families. This further simplifies the process of rendering polygons. As a result, the regular solids which were one of the major challenges in mathematics from Antiquity onwards, and the irregular solids, which became one of the major challenges of Renaissance mathematics, science and art, have in our day become routine, and almost entirely automatic exercises. Indeed major mathematical software packages such as Mathematica, provide for the construction of the basic Platonic and Archimedean solids as a matter of course. Meanwhile, scholars such as Loreto (Rome), at the frontiers of crystallography have developed complex programs that permit systematic treatment of all the solids electronically.

In the Renaissance, the use of linear perspective entailed the choice of a single relationship between the eye, picture plane and object and dealing with this from two positions (usually ground-plan and elevation). If the relationship between these three variables was infelicitous, one might well have arrived at a picture in which the view of buildings was cut off (cf. pl. 104.1). In an attempt to include the whole building one could then have used three-point perspective, which can be achieved simply by tilting the picture plane (cf. pl. 104.2), but this would have created what some now term parallax, or what persons in theatre term keystoning: visual effects that are usually unwanted, which is why Renaissance artists focussed on one-point perspective, used two-point sparingly and avoided three point perspective entirely.
Fig. 33. Assigning the lofter’s path to a camera in 3-D Studio. This illustrates how one can change viewpoints systematically to produce the equivalent of motion perspective.

The Autodesk solution in 3-D Studio is to move the distance of the eye and picture plane relative to the object such that the scene can be looked at under a much smaller visual angle. The particular scene that one would like to have is then framed (pl. 104.3) and blown up (pl. 104.4). In the Renaissance this would have required redefining each time the position of the eye, picture plane and object and thus arriving at four completely different pictures. Because the 3-D Studio drawing has all the co-ordinates for each building in the picture, one can move almost effortlessly from one to the other. The different views are effectively only a shift in scale. One can also move effortlessly from a one-point perspective view of the scene, to views of the scene in two-point or three-point perspective.

The full power of this Autodesk approach in 3-D Studio only becomes evident when we explore its consequences. We can change our distance relative to the objects in the scene in any way we wish. We can for example alter between a given position on the ground to a bird’s eye view. Alternatively we can change birds eye views. If these are combined in rapid succession we can effectively simulate the effects of motion perspective (cf. fig. 33). This leads to the flythrough effects that have been introduced by high-end software.
Conceptually this is of great interest because it shows how so-called motion perspective is achieved by an extension of rather than a rejection of the principles of linear perspective, contrary to the views of some recent scholars who have calimed that linear perspective is now “relatively irrelevant”, (see above p.104).

While it cannot be our purpose at this point to enter into all the technicalities of recent developments in terms of high-end software packages, it is useful to outline briefly some of the key concepts underlying Open GL (i.e. Graphics Language) used in Silicon Graphics workstations.

Renaissance perspective focussed on one set of co-ordinates linking the eye, picture plane and object.
Fig. 35-36. Two examples of perspectival principles being applied to contemporary ray tracing. From Robert Lansdale (1991, 14).

Fig. 37. An example of anamorphic principles of perspective being used in contemporary ray tracing. From Robert Lansdale (1991, 33).
In Open GL this relationship is termed eye-coordinates and along with object co-ordinates and clip co-ordinates constitutes one of three types of co-ordinates which are systematically integrated (fig. 26-28*). Hence, whereas Renaissance perspective was limited to the use of a single window, Open GL employs a windows approach in the literal sense, which is why one can have perspectival scenes within scenes in the Silicon Graphics, Kubota and other high end graphics environments. The full consequences of this approach are best seen through examples produced by Alias and SoftImage software. One can create photo-realistic views of real or imaginary rooms (pl. 105.1-2), or the interiors of entire buildings (pl. 106.1-2). These principles have been used in reconstruction of buildings no longer existent (pl. 109); in design, i.e. the projection of buildings that were only later constructed (pl. 107-108), and in futuristic buildings which may never be built (pl. 110).

**Lighting and Radiosity**

Basic to these developments has been the extension of perspectival principles to problems of lighting. In 3-D Studio lighting functions as either an invisible (pl. 113.1) or a visible pyramid, which can be projected through regular apertures to produce anamorphic images (pl. 113.2). Multiple lights can also be used (pl. 113.3), which can then be dimmed or altered to create atmospheric effects akin to fog (pl. 113.4). More complex software such as Lightscape uses radiosity (pl. 114.1-2).

Technically speaking a one-to-one correspondence is only possible in the case of vector graphics, where entire lines are copied. In the case of raster graphics the copying of points presents problems of aliasing especially in the case of distant objects. Even so it is noteworthy that the underlying assumptions governing perspective apply equally to pixel projection used in ray tracing. As Mitchell noted in *The Re-configured Eye*: “The basic strategy implemented by ray-tracing algorithms is to consider the picture plane as a fine grid of pixels placed between the viewer’s eye and the screen and to send a ray from the eye through each pixel to the scene.” Scholars such as Mitchell have also emphasized differences between the continuous lines of analogue methods and the discrete pixels of digital methods, suggesting that perspective applies only to the former. Lansdale, in a fundamental dissertation on the subject, has demonstrated lucidly how the principles of linear perspective can be extended to discrete pixels in ray tracing and radiosity programs. In traditional Renaissance perspective one often begins with a square tile parallel or at right angles to the picture plane and records its projected size. In Lansdale’s approach this procedure is reversed: i.e. a square pixel is treated in the manner of a projected square tile on the picture plane or screen and is then projected back onto the textured 3-D object. In this way the specific texels (unprojected pixels of the textured 3-D object) occluded by the projected pixel can be calculated. Although the direction is reversed, the projection of this pixel from a screen onto a textured object in modern perspective corresponds precisely to the projection of a square from a wall or pavement onto a perspectival window in Renaissance perspective. Seen in this way the recording of electronic pixels is analogous to a microscopic approach in recording tiles of a wall or pavement perspectivally (fig. 35-36). In other examples, a spherical shape on the picture plane or screen is projected as an oval shape onto the pavement positioned at an angle relative to the plane (fig. 37). This is precisely the reverse of an anamorphic form which
is projected as a regular sphere on a tilted projection plane. Hence perspective remains a valuable tool in understanding the frontiers of aliasing problems in image processing.

Until recently these operations were difficult and often infeasible from a sheer computational point of view. For example a screen of 1000x1000 pixels requires one million rays which meant that even a single object required hours and sometimes days to render. As computing power becomes ever more efficient and affordable more complex perspectival effects involving light and shade, colour and even aerial perspective are becoming increasingly popular.

**The Four C’s**

The principle of computer graphics was initially applied to Computer Aided Design (CAD). In the past decades this has been extended to include Computer Aided Engineering (CAE), Computer Aided Manufacturing (CAM), and these have in turn been coordinated to produce Computer Integrated Manufacturing (CIM).

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Fig. 38. The xyz co-ordinates system based on the observer’s eye position from Ivan E. Sutherland, “A head mounted three-dimensional display,” *Fall Joint Computer Conference*, 1968, p.761. Fig. 35. A computer displayed perspective view of the room as seen outside from Sutherland, as in note 27, p.763.

Taken together these are referred to as the Four C’s, a standard treatment of which is by Machover (1989). Some idea of the enormous growth in this field is given by the fact that the CeBIT computer fair at Hanover (1994) had two halls devoted to the latest developments in CIM alone.
Fractals
Building on the mathematical equations of nineteenth century mathematicians such as Julia, Mandelbrot (1977), established fractals as an independent field of study. This work was of major importance because it gave a philosophical foundation for a geometry of “formless form”, i.e. irregular, often organic, shapes in nature which eluded the net of Euclidean geometry. This led him to make a basic plea for the importance of visualization in mathematics as a direct attack on non-visualizing traditions epitomized by Weierstrass and his followers.

Barnsley (1986), offered an enthusiastic attempt to utilise the pragmatic potentials of these developments to the full. A second edition of Barnsley (1994), included applications of fractals with respect to photographic images. Peitgen (1986) (1988), has explored the aesthetic potentials of these new forms. Companies such as Imagician (1991), have begun to sell examples of the more beautiful fractals. The philosophical problems posed by fractals, outlined elsewhere (Sources, p.208*) have not received the attention that they deserve. At the popular level, a new software, Vistapro, allows one to create fractal landscapes which use elevation maps of real places as their points of departure (p. 10*).

Virtual Reality
In terms of perspective, virtual reality poses new challenges because it is essentially a combination of different perspectives. Typically this entails a context and then the viewer in that context. At other times this involves moving from an exterior (exogenous) view to an interior (endogenous) view.

The quest for what is termed virtual reality, artificial reality or cyberspace involves two basic types: one attempts to create this space for a single person although another individual with separate equipment can enter into that space; a second type attempts to create a total environment that can be shared by a crowd, or at least by a group of spectators. The quest for an individual space has proceeded on at least three fronts: the cathode ray tube; the head mounted display and the binocular omni-oriented monitor. The quest for a total environment has also developed on several fronts. Following a survey of general literature on the subject, each of these will be considered in turn.
Fig. 39. Main commands of the World Editor from Dimension International.

Rheingold (1991), gave one of the first popular introductions to virtual reality, a theme which he pursued in *Virtual Communities* (1993). While both of these books touched on implications of virtual reality for concepts of space, neither provided any detailed analysis. Pimentel and Teixeira (1993), provided a more detailed technical coverage of North American developments. Also useful in this context was a book by Aukstalanis and Blatner (1992) which gave useful insights into technical challenges of virtual reality, but was rather weaker in assessing contributions of the key individuals. Hamit (1993), included a chapter with a promising title: “From the stereoptikon [i.e. stereoscope] to the holodeck: the history of an idea” (39-52) which, alas, was rather minimal in its historical content. Wodaski (1993), gave concrete examples of applications of Vistapro and 3-D Studio. Larijani (1993), illustrated information projected off screens as 3-D images with hardware by Stereographics, a reconstruction of the Abbey of Cluny by IBM’s Visualization Power Series (pl. 109.2), mentioned problems of sizing and perspective (69-71) and surveyed applications of virtual reality to a number of fields includng,
medicine, architecture, entertainment, education, home and office, manufacturing, science and engineering, military, customer creation, and erotica.

Benedikt (1991), considered to be the first scholarly book in the field, was of particular interest mainly due to plate 1 by Daniel Wise which showed: “one vast 3-D data cell providing access to a visual data base. Data available at the intersection of the three crosshairs opens into a subspace of three further dimensions”. Laurel’s (1991), study which focussed on the philosophy of electronic searching, included some spatial treatments: Ron Gilbert’s, The secret of monkey’s island and Autocad 3-D Studio.

Wexelblatt (1993), in the best scholarly collection of essays to date, included three articles on data visualization. Of these, the most stimulating was Fairchild, who considered Xerox Parc’s Perspective wall visualization and their Cone tree visualization; Silicon Graphic’s 3-D Fusion Information Landscape Prototype and the Institute of Systems Science Sphere visualization. Also of interest was McGreevy’s “Virtual reality and planetary exploration” (163-197) and Grantham’s article on organizational modelling techniques (219-257). Two of the earliest serious bibliographies were McLellan’s (1992) Virtual Reality. A Selected Bibliography (Educational Technology Selected Bibliography Series) and (1993) VR R&D. A directory of research projects.

Cathode Ray Tube (CRT)
The simplest type of virtual reality effects are produced using a cathode ray tube or single monitor to which stereo images and viewer directed perspective are added. Sometimes two such screens are combined in order to achieve a stereoscopic effect. What distinguishes these screens from those of an ordinary computer is that the user can navigate within the represented space. This can be done in several ways. For example, in the Superscape Virtual Realities System, one can follow the motion of a pedestrian, or one can become united with the motion of the pedestrian. One can observe the motion of an automobile from outside or from inside the car. Alternatively one can view the scene from outside a helicopter. In other words one can move at will from an egocentric to an exocentric viewpoint.

At the 1994 Siggraph show (Orlando), Apple demonstrated a new low-end form of virtual reality used in the reconstruction of panoramic views of interiors and exteriors. One begins with eight photographs of an interior. These are then co-ordinated such that overlapping areas are eliminated and mapped onto the interior of a cylinder, i.e. transformed into cylindrical perspective, such that one can see the scene as a single panoramic view. In the case of exterior views a similar principle applies except that the images are projected onto the exterior of a cylinder. Because these transformations are systematic it is possible to revert from this artificial view back to the co-ordinates of the original photograph.

Head Mounted Display (HMD)
As Rheingold (1991), has noted in his very useful survey of recent developments in the field, one of the early pioneers in this domain was Morton Heilig whose Sensurround (1954), was effectively an arcade video-game type of space, which included effects of sight, sound and smell. The idea of placing this space within a set of goggles was proposed by Ivan Sutherland (1965), one of the pioneers in the field of computer
graphics. Preliminary experiments were done in 1966 and 1967 before Sutherland (1968), published his paper on “A head-mounted three-dimensional display” (fig. 34), noting that it was based on the idea of presenting “the user with a perspective image which changes as he moves”. His system used a mechanical head position sensor and an ultrasonic head position sensor. He cited a term paper (MIT, 1965) by Dan Cohen which gave *A program for drawing bodies with the hidden lines removed* and a thesis by Haynes (Austin, 1966) on *A computer method for perspective drawing*. At about the same time, Thomas Furness III, was working on the Super Cockpit at the Wright Patterson Air Force Base which entailed a million dollar head mounted display used for purposes of flight simulation.

A breakthrough in the development of less expensive systems came at the N.A.S.A. research labs at Mountainview in 1986. The research team which included Stan Fisher and Warren Robinett introduced several new items. They used a more portable head mounted display. Inside this device were two television cameras positioned in front of the eyes to produce stereoscopic images giving one wire-frame equivalents of a spatial context. Different about this space was that it was linked with a so-called power glove produced by VPL that permitted coordination of a fictive hand within this space with actual movements of one’s own hand. This meant that one could manipulate objects within the fictive space and play with scale such that a large box-like room in which one appeared to be contained and could a moment later be reduced to a box outside of which one stood. The N.A.S.A. laboratory remains one of the frontier institutions in the field despite budget cuts and changes in personnel.

Warren Robinett, whose career had previously involved the video-game *Rocky’s Boots* at Atari, was one of the key individuals in the early development at N.A.S.A., and went on to direct the Head Mounted Display Project at Chapel Hill (North Carolina) in the department of computer science headed by Fred Brooks. Besides an initial video at NASA (1987), Robinett has written important articles and produced two excellent videos (1990, 1991), which explore some of the principal applications of the device in terms of chemistry (molecular docking), architecture (simulated walk-throughs), medicine (simulated radiation and chemotherapy). Another of the major players in these developments is Thomas Furness, III, who for many years directed research in this area at Wright-Patterson Air Force Base and in 1989 founded the Human Interface (HIT) lab at the University of Washington (Seattle). In contrast to other colleagues he has been exploring the feasibility of projecting laser images directly onto the retina.

A third individual, Jaron Lanier, whose company, VPL, produced one of the standard power gloves in the field until 1992, has developed his own virtual reality demonstrations for a variety of fields including architecture, design and entertainment. Like Brenda Laurel, who links virtual reality with the Aristotelian concepts of catharsis applied to the theatre, Lanier is intrigued by the possibilities of using these new devices to create individual phantasy worlds, personal versions of traditional myth and religion.

While the research labs at Mountain View, Chapel Hill and Seattle have focussed on the frontiers of research using very expensive equipment, a few individuals have been concerned with producing simplified versions that would come within the orbit of a personal budget. Lanier’s company, VPL, which is now being continued by his former partner, Rameau, was one of the pioneers in this area. In 1988, Autodesk announced its
plans to join this quest, but suffered a major setback when two of their key persons, Eric Gullichsen and Patrice Gelband, set up their own company, Sense 8, which produces the best of the affordable versions. The Straylight Corporation (Warron), has produced (1991) Photorealistic Virtual Reality (Photo VR) which permits direct imports of three dimensional designs from Autodesk’s 3-D Studio, AutoCAD and Autoshade or AT&T’s Topas Animator into a virtual reality environment. Division Incorporated produced (1992) Provision 100VRX, described as “the first in a new generation of 3D visualization systems”. It combined an “Intel 486 platform with dedicated stereographics, three-dimensional audio and low latency virtual world interactivity”.

Graham Smith (Toronto), developed Horizon Scan. This involved filming a 360 degree view which was then viewed in a head mounted display with two monitors. Working together with the Vivid Effects Group he created an interactive programme that allowed viewers to reach out into this 360 degree analogue horizon and activate digital images within it, thus combining analogue and digital inputs.

Binocular Omni Oriented Monitor (BOOM)

The BOOM alternative was used in one of the first demonstrations of virtual reality by Sutherland (1968) at the University of Utah (Salt Lake City). It involved an apparatus like a periscope, through which the viewer looked, which could be raised, lowered and rotated. More recently such an apparatus was suspended from an articulated arm which measured its position and orientation in space and counterbalanced its mass, in the virtual reality project designed by Martin Tuory at Alias, which was cancelled in 1992. This version of a BOOM was operated manually by the viewer. Meanwhile BOOMHD, BOOM2 and BOOM2C have become trademarked names of Fake Space labs (Menlo Park), which are linked with a Molly: “a teleoperated motion platform which can be outfitted with cameras to transmit images from remote locations. When coupled with a BOOM, the Molly can pan, tilt and roll in real time to approximate a user’s head motion, thus giving a feeling of telepresence”.

Total Environment

Total environments are of three main types: those which attempt new links with other media; those which use cinema to recreate optical space in a realistic way and those which use head tracking devices. The first of these typically links different kinds of visual space or coordinates visual and auditory space. Myron Krueger (1983), a pioneer in this field, wrote a significant autobiographical account of his experiments in this field. This he updated in Artificial Reality II (1991). Here he reviewed three of his early demonstrations involving interactive environments: Glowflow, Metaplay and Psychic Space. These led to Videotouch (1972) and then Videoplace (1975-) which began with two persons in two different rooms sitting in front of a computer screen. Their respective actions were filmed by video cameras, correlated to form a composite image, then displayed on a monitor in each of the two rooms. Through this video communications link the two individuals had a sense of touching each other.

These installations were developed in the Milwaukee art museum (1975-1977), at the University of Connecticut (1978-1985), and subsequently on an independent basis from his home in Vermont. Many of the interactions which had real time dialogue between two
persons in different environments had witty names including: Critter, Videosyncrasy, Vidiocy, Mandala (which arranged seven copies of an individual’s silhouette on the screen and had nothing to do with the Toronto based group of the same name), Manipulate, Telecision and Balloonacy. He also described in some detail his Videodesk which, in addition to being a virtual desk for writing, also permitted three-dimensional art and “sculpture “ (see below p. 165**). Most of these experiments were demonstrated by two videos in Krueger (1990, 1991).

In Toronto, Bo Gehring and David Rokeby created a Very Nervous System, which linked motions of the hand in space with musical notes produced through a synthesizer. This produced completely virtual orchestras using movement through space and sound. The Mandala System, produced by Vincent John Vincent and the Vivid Effects Group (Toronto), took these ideas further by allowing correlation of (real) hand movements with images of different instruments to produce corresponding (real) sounds from such instruments. What sets the work of Krueger, Gehring/Rokeby and Vincent apart from other experiments in virtual reality is that the user is unencumbered by heavy equipment, while still being basically alone.

A second type of total environment, which aimed at optical veracity, can be seen as a direct growth of the panorama tradition combined with the notion of cinema. Conscious of the limitations of ordinary projection screens, film makers explored various alteratives such as Cinerama which included three projectors but entailed serious problems in correlating the three views. Todd-Ao offered a somewhat better solution but even so limited the horizon to 120 degrees. A Russian solution employed twelve cameras in order to create a full 360 degree view. The history of these experiments has been documented by Carr and Hayes (1968), and Hayes (1989), who focussed on developments in 3-D and stereoscopic cinema.

The secondary literature has only begun to take into account Canadian developments in this field which have set a world standard in this context. The IMAX film company produced a 75 millimeter film particularly designed for wide angle screens typically six stories high. OMNIMAX, a development of this idea, entails an even larger screen that involves a viewing angle of some 260 degrees. The IMAX MAGIC CARPET extends this horizon even further by positioning the viewer on glass seats such that images can be projected below as well as above. The history of these developments was outlined in a video entitled Putting you in the picture by Ted Regan Productions (1988).

IMAX 3-D uses stereoscopic glasses to view objects in stereo. A preliminary demonstration was given at the Osaka World Fair (1990). IMAX SOLIDO combines the IMAX wide angle technology with stereoscopic viewing glasses to produce fully realistic three dimensional images. A first demonstration of this principle occurred in the form of a short film, Echoes of the Sun, using computer graphics which was shown at the Fuji Pavilion at the Osaka World Fair (1990). This principle was developed to incorporate 360 degree stereophonic sound and films of live situations in the years 1991-1995. The idea of the total environment is not limited to the cinema. The OMNIMAX MAGIC CARPET methods have been adapted in producing a simulated Back to the Future ride for the theme park at Universal Studios (Orlando, Florida).
A third approach to total environments is through an Audio Visual Automatic Virtual Environment (CAVE) which involves a cube shaped room all the walls of which have display screens. The viewer wears a head tracking device which adjusts the perspective and stereo projections of the environment as the viewer moves within it.

The surveys of Aukstakalnis/Blatner (1992) and Pimentel/Teixeira (1993) have emphasized that virtual reality is by no means limited to visual aspects: it involves auditory, tactile and potentially even olfactory inputs. As such it implies a new synaesthetic approach to all the senses rather than a single sense in isolation.

These surveys have also drawn attention to the essential role of tracking with respect to visual aspects, noting that the Polhemus tracking device which uses magnetic waves is but one of five methods along with mechanical, ultrasonic, optical and image extraction. Herein lies one of the essential differences between virtual reality and linear perspective as it was developed in the Renaissance. Linear perspective was concerned with establishing a vanishing point from a given, static position. Virtual reality is concerned with tracking motions of an observer within a space. As a result the changing viewpoints of the individual can be traced and potentially so too can all the other viewpoints within this space. This explains the ability of virtual reality systems to move interchangeably between ego-centric (endogenous) and exo-centric (exogenous) viewpoints.

One of the initial incentives for the development of virtual reality lay in the visualization of topics outside the scope of ordinary vision. As Sutherland (1968), noted (22):

> We lack corresponding familiarity with the forces on charged particles, forces in non-uniform fields, the effects of non-projective geometric transformations, and high energy, low friction motion. A display connected to a digital computer gives us a chance to gain familiarity with concepts not realizable in the physical world. It is a looking glass into a mathematical wonderland.

As Pimentel (1993), has pointed out, these potentials of virtual reality in visualising data are being extended into many unexpected areas (164-165): “the flow of energy through a living creature or ecological system- or the accumulation, distribution, and use of dollars within a company, business or local government.” He added that “if these transactions can be meaningfully packaged into a visual metaphor, a viewer could watch several days in the life of a company go by in a few seconds”. This precisely what companies such as Visible Decisions (Toronto) are doing. Hence virtual reality is leading in two quite different directions: on the one hand it entails an ever more precise tracking and recording of spatial co-ordinates and viewpoints in the physical world. On the other hand it is inspiring ever more attention to “seeing” things which have no simple correspondence to the physical world.

For our purposes this second trend is the more interesting because it also represents a dramatic change in the meaning of metaphor. As was noted earlier (Sources, II.4) the rise of metaphor and perspective were connected. Both had their basis in physical objects and both established a potential one to one correspondence between original objects and image. A person who uses virtual reality to represent changes in the stock market with fields of grain that grow taller and shorter is doing something different. A stock market is a reversible process: a grain field in nature is an irreversible process. Hence there can be
no simple correspondence between the two. Some may claim that this merely amounts to a new kind of stretching of the meaning of metaphor.

We would suggest, however, that a more fundamental change is involved. Renaissance metaphors used one concrete image from natural experience to augment our understanding of another experience: “Life is a walking shadow”. The new metaphors of virtual reality use familiar images to translate the non-visible into graphic terms, which is very different. There have been at least three recent attempts to classify some of the major categories of visual experience using these new technologies: Naimark (199*), Robinett (199*) and Veltman (1994). Some of the problems posed by these developments are explored in the chapter on transformations (see below p.20*).

**Integration of Space and Time and Virtual Reality**

In the realm of computer software, new approaches to space and geography mark some of the most dramatic areas of development, which also evidence trends towards convergence. Scanned versions of traditional road maps are being made accessible by CD-ROM. A detailed map of Germany is available for c. 1000 DM. This is being coordinated with satellite images and linked with geo-positioning devices. Hence transport and despatch companies are able to trace in real time the locations of their various trucks, which is not only in the interests of efficiency experts but also potentially valuable in tracking stolen materials. Plans are underway to provide all expensive cars (e.g. Mercedes Benz, Porsche, BMW) with such geo-positioning devices such that they can be tracked when stolen.

Police departments are also adopting this technology in tracking the exact position of both their own cars and in locating the relative position of fugitive cars. Adaptations of this technology are leading to integration of maps with video records of public places such that a police official is able identify the scene of a crime on a map and, in many cases call upon a video showing the precise building(s) of the crime. There is talk of integrating these maps with the real time videos already in place in most banks, subways and public places such that a centrally located officer can literally be at the scene of the crime at a distance. Dornier has developed perhaps the most impressive version of this software which is currently being used in seven German cities, and slated for use in a further thirteen. Philips, MAN, IBM, Panasonic and others have their own versions of these technologies. Dornier’s software is the more interesting because they have developed links with Geographical Information Systems (GIS), partly in conjunction with Intergraph, and have also developed a version of their electronic map on a notepad for use in helicopters, which re-orient itself as the airborne vehicle changes direction.

One of the interesting developments in nineteenth century perspectival instruments were methods to translate oblique photographs of a landscape with regular maps of the same area (pl. 87.1-3). Twentieth century instruments have focussed on ever greater accuracy in transforming information from a curved or irregular picture plane with flat surface planes of maps. Scholars such as Brandenberger (1985) have provided a theoretical basis for these transformations (pl. 88). In terrestrial surveying these transformations have been greatly improved in the context of photogrammetry (p. 89-90). In the context of surveying from space, work is underway to correlate satellite maps with topographical maps, (a topic also being studied at the ETH in Zurich), such that one can transform the
two-dimensional satellite image into a three-dimensional CAD reconstruction of the scene (pl. 91-92). In the case of static maps this process has already reached demonstrable results. It is estimated that within three years this process will be extended to real-time situations. This has enormous implications. In military terms, it means that a pilot in a helicopter could fly over a forest in complete fog and still “see” fully three-dimensional images of the landscape above which they are flying using dynamic CAD.

There is no doubt that these developments pose a whole range of new dangers in the direction of total surveillance and the spread of an Orson Wells 1984 type police-state. It is important, however, to recognize that these same developments offer enormous potentials in non-military applications. They mean, for instance, that the kind of fly-past techniques initiated by Jimmy Blynn at the Jet Propulsion Lab with respect to an imaginary journey above the planet Mars can be applied to any place on earth. In the past there have been considerable efforts on the part of the U.S. to classify information of satellite images in scales less than 80 meters. One of the unexpected results of the so-called fall of communism is that Russia is now selling images from its former spy satellites to scales of .5 meters. In short material originally connected for military purposes is now becoming available for peaceful uses.

It is to be hoped that this trend will spread equally in the case of the new techniques which are being introduced in the interests of law and order (police departments) and security (insurance companies). The same information can be used to provide tourists real time fly-throughs of the area they are planning to visit. Scholars will be able to study monuments at a distance and still get a sense of their spatial context: how a building relates to its surroundings, to a given section of town, and to the general environment. When retrospective photographs and map materials are made available in digital form it will be possible to do morphs of changing cities and the interactive relations between cities and the surrounding landscapes. This will transform our understanding of urban history, of ecological and environmental studies because we will for the first time gain insights dynamically into the changing relationships between natural and man-made environments and be able to trace where those relationships move from a delicate interaction to a clear imbalance.

In the past decades there have been trends to record the physical world in the form of satellite images, photographs and video-cameras. At the same time there have been parallel trends to reconstruct the world in terms of CAD particularly in the context of GIS. More recently this trend has been extended to the realm of Area Management and Facilities Management (AM/FM). These concerns have shifted from the purely military to public and private surveillance bodies (police, insurance), to public administration, notably in the case of services (e.g. hydro, telephones, sewers). Needed is a framework that makes these readily accessible for both public and private use (without of course jeopardizing the integrity of documents that are fundamental for the development of the community, province and country).

The new electronic media are also transforming our approaches to time and time based phenomena. The integration of moving pictures (video, digital TV, digital films) and moving words (audio presentations, voice recognition, music) are rapidly becoming a part of all multi-media software. Desktop video-conferencing is another example.
Telepresence has become a buzzword. At CEBIT, there was some evidence of projects in the realm of searching for, consulting and editing specific elements of material entailing continuous motion. Projects at Canadian institutions such as Ryerson and Toronto appear to be further advanced on these problems. Even so there is a clear need for an integrated approach that will embed these functions within a larger knowledge framework such that these operations can be accessed seamlessly without requiring special equipment (e.g. n-Views which promises to expand the approach of the Video Toaster to various forms of continuous media on different platforms).

A project at the School of Landscape Architecture (Toronto) is being developed in conjunction with three other centres: the Graduate School of Design (Harvard), MIT, and the ETH (Zürich). This entails an integration of digital terrain maps, remote sensing, GIS information (Arc Info), and CAD programmes (AutoCAD) in a single system, complete with a personal editing software, Polytrim.

There are presently twenty major projects in virtual reality underway in Japan alone, although very little is known about these in the West. A standard book on the subject by Hattori (1993), in Japanese, has not been translated. In Germany, the Gesellschaft für Mathematik und Datenverarbeitung (GMD) has developed a number of experimental applications for virtual reality: notably, museums, medicine and engineering. A project at the University of Stuttgart is exploring real time medical fly-throughs that remind one of the science fiction film Fantastic Voyage. In conjunction with engineers from Dresden, who have developed new techniques for translating information from photographs of individuals stones into a 3-CAD version, IBM has produced an elaborate virtual reality version of the Frauenkirche in Dresden, the former monastery at Cluny (pl. 109.2) that was the subject of a recent lecture by Professor Philippe Céau at the Marstall Theatre (18.3.1994) sponsored by the Siemens Foundation; and the ancient city Pompeii.

10. Conclusions

Perspective provided an objective method for recording the physical. Ironically its applications to scenography, although they entailed a new confrontation with views of real cities (cf. below p. 155*), entailed many idealized and imaginary views also. In the case of marquetry a similar process obtained: rather than becoming a strict record of the natural word, it served primarily as a testament to the world of man’s artifice. While many examples of inlaid wood were limited to choir stools, it was noted that some covered the walls of studiolos of Renaissance dukes and duchesses. As such it was related to traditions of trompe l’oeil which aimed at extending the apparent dimensions of rooms through illusory windows, doors and other apertures. It was shown that the tradition of quadratura aimed at similar effects in terms of ceiling painting. It was shown that there were curious interplays between fictive painted spaces and constructed spaces, such that from the outset perspective affected architecture and eventually spread to gardens and the environment. With respect to alternative methods the literature on inverted perspective, anamorphosis, cylindrical perspective, spherical perspective and variant methods was considered. It was shown that a number of these alternatives were invented in an attempt to objectivize or mathematicize what have traditionally been considered as subjective aspects of vision.
Finally in the context of instruments and machines fundamental shifts were noted. Renaissance perspective instruments served mainly as extensions of the artist’s hand; instruments which helped artists and others in the processes of recording objects and demonstrating the results. By the seventeenth century instruments such as the pantograph were concerned with the problem of transferring images, reproducing them in the same or in different scales. These techniques were perfected in the course of the eighteenth, nineteenth and early twentieth centuries. The past century brought the invention of photographic cameras which potentially recorded images of objects with no human intervention beyond pressing a button. Since the 1950’s, the rise of electronic media introduced a new range of instruments which effectively integrated the principles of perspective into their software such that it is increasingly becoming a tacit framework in drawing packages as well as more specialized CAD programs. We suggested that this might account for a new fascination on the part of artists with alternative methods of perspective. It was noted that the latest developments in virtual reality permit one to enter into different spatial systems; i.e. literally to be confronted by other cultural frameworks, the philosophical and other implications of which remain almost fully unexplored.
V. APPLICATIONS-METAPHORICAL

1. Introduction

Thus far we have focussed on the uses and applications of linear perspective and its variants in a technical sense. In some positivist programmes of the nineteenth century this focus would have defined the limits of the field. Metaphorical uses of perspective in terms of point of view, standpoint, position, or even plan, either of an individual or a society, would not have been included. Our reason for doing so is simple. Metaphors of perspective have become much more than clever or elegant turns of phrase. Particularly in the twentieth century a significant number of authors in various fields of the humanities and social sciences have developed what they believed to be coherent systems based on this metaphor and used these to explain basic aspects and developments in the history of literature, philosophy, ethnology, anthropology, psychology, psychiatry, linguistics, sociology and even theology. These attempts are the more significant because they are intimately connected with fundamental debates concerning methodology in all domains of the arts and sciences and closely related to important trends toward psychological and sociological interpretations.

In the Sources we distinguished between pseudo-perspective (non-homogeneous representations of space), proto- or empirical-perspective (early approximations of perspective), and technical use of linear perspective. In the case of metaphorical perspective, analogous distinctions are necessary between pseudo-metaphorical perspective (notions of viewpoint in unhomogeneous space), empirical metaphorical perspective (the emergence of an approximately accurate viewpoint) and metaphorical linear perspective (conscious, systematic use of viewpoints). By way of context we shall mention in passing some basic examples of pseudo- and empirical metaphorical perspective in literature. Our emphasis will be on the development of conscious metaphorical perspective, major authors who use the term in the titles of their works and specifically with regard to systematic methods. Since a search for every reference to viewpoint or perspective merely used in passing would expand the topic far beyond the bounds of this study, there will be no attempt at completeness as was the case with the sources.

2. Literature

In literature, the origins of pseudo-metaphorical perspective in the sense of point of view are not clear. Among the earliest examples of looking at things from changing points of view, first from the earth and then with increasing distance from the heavens can be traced back to the fragments of a Babylonian poem. While the oldest surviving manuscript of this story comes from the library of King Assurbanipal (660-627 B.C.), it is linked with a fragment over a thousand years earlier (c. 1750 B.C.). In the poem, Etana, the father of the future king of the world attempts to bring a magic plant back from heaven. Schäfer (1974), who includes this text in an appendix, describes it vividly: “The
eagle tells Etana to look down three times each time after a league’s ascent. Each time the world appears smaller. Thus after the first league the land mass and the ocean surrounding it are like an island in the river; the next time like a garden with a ditch around it; then in succession like a hut in a courtyard and a roll on a plate”.

Plato, in his literary theory, introduced a dichotomy between narrative (diègèsis) and drama (mimèsis) with epic poetry as an intermediate form (modus mixtus). Aristotle made a related distinction between epos (diègèsis) and drama (direct imitation). These have formed a starting point for more recent distinctions among literary historians concerned with point of view theory (see Appendices 6-8). Kurth-Voigt (1974) argued that the principle of confronting different viewpoints in the sense of differing levels of knowledge became a basic theme in the dialogues of Plato, Cicero and Lucian and that these three authors provided: “diversified, at times highly controversial models for the art form of the dialogue and the presentation of various subject matter from multiple points of view”.

Hanfmann (1957) argued that the development of realism in Greek sculpture and painting affected the development of new narrative techniques in Greek literature: i.e. that the mastery of spatial viewpoints in art led their being used in literature. On the other hand, Gombrich (1960) suggested that the converse occurred: namely that new narrative techniques in literature inspired the so called revolution in Greek art. Others have claimed that the Greek dialogues were rhetorically and logically constructed in such a way that they excluded the existence of personal viewpoints, let alone the comparison thereof. Auerbach (1945), for instance, in his great Mimesis, suggested that there was a fundamental distinction to be made between the one dimensional literature of the Greco-Roman tradition and the spatially much more realistic literature of the Judaeo-Christian tradition and if he be right then it was in this latter tradition that the notion of point of view in literature had its roots.

De Folter (1983) claimed that the problem of reciprocity of perspectives went back to the Greek sceptical tradition founded by Pyrrho of Ellis. He noted, for instance, that the Greek verb from which scepticism derives, skeptomai (to look around, to spy, to observe), is etymologically linked the Latin verb, specio, (to see), which is one of the roots of the noun 'perspective'. It was no coincidence, therefore, claimed de Folter, that sociologist-philosopher, Schutz (see below p.), in his Problem of Relevance, should have dealt with Carneades of Cyrene, the founder of the third Academy, who introduced new elements into the sceptical tradition.354

Stempel (1972), claimed that the earliest concrete evidence for literary perspective—we would say empirical or proto metaphorical perspective—could be traced back to French literature in the twelfth century; that in the writings of Chrétien de Troyes (c.1135-1183), one found a deliberate mixture of indirect and direct speech which should be seen as a branch of perspective in the sense of point of view technique. Meanwhile, Kuhn (1949,1966,1973), placed these discussions in a larger European context, noting that the mediaeval courtly love poetry which evolved with the Provencal troubadours in the twelfth century spread throughout the whole of Europe and in Germany inspired a particular form of lyric love poetry (Minnesang). Kuhn was careful to insist that the mediaeval concept of objectivity was not to be equated with that introduced by Renaissance perspective. Nonetheless, he compared the courtly epics of Chrétien De Troyes with those of Hartmann von Aue (d. c.1210-1220), the first of the German courtly
love poets; Wolfram von Eschenbach (c.1170-1220), the author of *Parsifal*; and Gottfried von Strassburg (fl. c.1200), the author of *Tristan*. In the case of Hartmann von Aue, he drew attention to a dialectic between the viewpoint in the opening stanzas of the poem and the main body of the poem. Green’s (1982), study of Wolfram’s *Parsifal* remains the most thorough examination thus far of these point of view techniques in mediaeval German literature.

As we have noted earlier (see above p.27**ff.**), this French connection with the origins of point of view in literature is the more interesting through parallels with art history. Saint Francis of Assisi, it will be recalled, received his name because of his relations with Provençal French culture, particularly in terms of their storytelling. It can therefore be no coincidence that it was precisely in the Franciscan tradition radiating from Assisi that a new approach to pictorial narrative emerged in which spatial aspects and subsequently perspective played a central role? Or that the advances in secular art in Italy were frequently linked with France, as in the cycle by Azzo in the old town hall (now Civic Museum) of San Gimignano (c. 1295-1300)? This was also reflected in the art of Simone Martini, whose predella of the altarpiece of *Saint Louis of Toulouse Crowning Robert of Anjou* (1317) was described by White (1957, 83) as “the first surviving example of the perspective grouping of several scenes about a clearly defined central axis” and whose later activities included a period at the court of Avignon. In Florence, the French courtly love poem, *The Chatelaine of Vergi*, was the inspiration for narrative scenes on the walls of the Palazzo Davanzati (Florence, 1395), on the occasion of the marriage of Francesco Tommaso Davizzi with Castelana degli Alberti, scenes which were among the first to use illusionistic treatments of architectural space somewhat systematically. Or one thinks of the frescoes in the Palazzo Trinci in Foligno (c. 1400-1450), with their French captions.

In Italy, as Parronchi (1960), showed (see p. 43*), Dante made some of the earliest literary references to perspective in the sense of optics. Guillen (1968), noted that the metaphor of linear perspective evolved in sixteenth century Tuscany both in the cultured writing of a Giovan Maria Cecchi (1518-1587), and in popular carnival songs with stanzas such as the following:

> If wealth, wisdom and faith are falsely rendered from the outside by colour, then he who believes in the clothing of those [deceivers] errs more than the others; for their language, intellect and heart are full of unpleasant traits and their being so pure and neat is but a sign of this; and it all derives solely from the fact that the whole world is done in perspective.

Constance (1976), analysed how literary perspective in the sense of point of view evolved in Ariosto’s *Orlando Furioso*; how the protagonist’s quest embroiled them in a complex play of masks and veils which multiplied the number of literary viewpoints and how this related to other examples of Renaissance romance notably Malory’s *Le morte Darthur*, and Spenser’s *The faerie queene*. Spenser’s use of literary perspective in *The faerie queene* was also outlined by Kamholtz (1980).

It has been suggested that because protestantism made them so sceptical of visual images the English became champions of visual imagery in their literature, thus compensating for perspective in painting with literary perspective. Whatever the cause, the phenomenon emerged clearly in the last three decades of the sixteenth century. As
Weimann (1970), noted these decades brought a volley of new literary forms: the euphemistic story (Lyly); courtly-gallant romance (Sidney), prose pastorale (Greene, Lodge), homely novel (Gascoigne), tradesmans’ romance (Deloney), picaresque genre (Nashe) and jest books. Of these, particularly the jest books introduced a new level of first person narrative and a more developed point of view. In a subsequent article, Weimann (1976), argued that the tensions between first person narrative and a represented point of view increased the gap between true meaning and fictive representation, thereby heightening the significance of both fiction and truth. Unfortunately he offered few examples.

Kayser (1963), considered perspective in terms of different spatial relations between viewers and the stage, noting that in the Mediaeval period viewers walked around the stage whereas in the Renaissance they were limited to fixed seats. Pfister (1974), building on this and the ideas of Klotz (1969), Van Laan (1970), and Pütz (1970), produced a typology of Elizabethan and Jacobean comedies. Pfister claimed that drama potentially involved an interplay of two communication systems: one, interior in which the persons on stage communicated with one another directly; the other, exterior in which the author indirectly steered the reactions and interpretations of the audience. He then outlined three variants: an a-perspectival drama, a closed perspective structure and an open perspective structure. In the first of these an author makes no distinction between interior and exterior communication systems, such that the author’s thoughts and intentions are indistinguishable from the words of the figures on stage. Pfister suggested that this structure obtained in the early morality plays of the period.

In a closed perspective structure the author consciously distinguishes between the two systems (inner and outer), and structures the play such that there is a growing discrepancy between the knowledge of the audience and the lesser knowledge of any of the figures on the stage. The knowledge which the audience gains is moreover clearly planned by the playwright to lead to fixed conclusions and in this sense is a closed perspective structure. This, Pfister claimed, obtained in Elizabethan comedies such as *Jack juggler*, *Ralph roister doister* and *Grammar Gurton’s needle*. By contrast, when the interplay between inner and outer communication systems is much richer, and no longer limited to a fixed conclusion, it entails an open perspective structure. This was the case in Shakespeare’s *Merchant of Venice*, *Richard II*, *Julius Caesar*; his problem plays such as *Measure for Measure*; a romance drama such as his *Tempest* and contemporary works such as *The revenger’s tragedy*, *The white devil* and *Bussy D’Ambois*.

A quite different approach was taken by Gilman (1978), who was concerned with specific examples of perspectival images in English literature of this period. Gilman noted the development of anamorphic methods in painting and explored the spread of this curious perspective in England. He claimed that Shakespeare, particularly in *Richard II*, was concerned with perspectives of history, whereas in his comedies, Shakespeare aimed at a natural perspective. Gilman claimed that Donne, Herbert, and Greville explored a Pauline perspective, while Marvell developed a perspective of the mind.

As the reader will have noticed there are really two stories that need to be told: one, how the authors themselves became conscious of the potentials of combining different viewpoints in writing their plays, poems and stories; the other, how critics became aware
that viewpoints offered a powerful tool in analysing works of the past. It is important to remember that while the evidence cited above suggests that the first of these stories emerged in the twelfth century, the second of these stories did not begin until the latter half of the eighteenth century, and then quite specifically in Germany. Böckmann (1966), in a fundamental article has demonstrated that German authors of the latter eighteenth and early nineteenth centuries played a seminal role in developing this interest in metaphorical perspective as a tool for both the criticism of existing and production of new literature.

Prior to Lessing, the German stage was dominated by a tradition that came from the Italian opera, either directly or via Paris, as Smart (1989) has shown, and emphasized the literal use of perspectival scenery. Lessing, according to Böckmann, applied what had been an external use of space to the interior world and developed a perspectivism of passions (Leidenschaften). For instance, in his Seventeenth letter on literature, Lessing asked how the German mind could utilize the possibilities of drama for itself and apply perspective to the basic principles of tragedy. Lessing’s search led him to re-interpret Shakespeare whose role he likened to that of a perspectival instrument: “If we have genius then Shakespeare must be that which the camera obscura is for the landscape painter: let him look carefully in it in order to learn how Nature projects itself onto a wall in all cases.” Elsewhere Lessing articulated precisely wherein lay this new perspectival goal of the dramatist for which Shakespeare offered a model: “What then is perspective for a poet or an author? It lies therein that he sometimes interrupts the temporal sequence of events in which his imitation develops and goes to other periods in which the objects which he wishes to describe found themselves earlier, until he once again takes up the thread of his present temporal sequence.”

Böckmann has shown how Lessing’s perspectivism of passions was developed into a perspectivism of individualism and history by Herder in his Pages of German kind and art (1773); a perspectivism of art and life by Goethe in his Shakespeare and no end (1813-1816); a perspectivism of phantasy and dreams by Tieck in his Poet’s life and how Schlegel subsequently went on to make perspectivism a basic principle of Romantic art in his Lectures on dramatic art and literature. Renaissance authors had frequently compared sculpture and painting (paragone). Schlegel contrasted ancient sculpture and theatre with Romantic painting and literature:

Sculpture directs our attention exclusively to the group that has been represented, stripping it as much as possible from all its surrounding contexts.... By contrast, painting prefers to represent the principal figures and all the surrounding features thoroughly and to open up views into an endless distance in the background. Lighting and perspective are its actual magic. Hence the dramatic, particularly the tragic art of the ancients, destroys to a certain extent the surroundings of time and space, while the Romantic decorates its more complex pictures through the interplay thereof [i.e.space and time].

This was clearly one of the starting points for the later nineteenth and twentieth century contrast between Ancient sculpture which was supposedly tactile and Renaissance painting which was supposedly visual—a distinction which Gombrich (1960), reviewed and challenged.
Kayser (1954), related the development of a specific viewpoint with the rise of the modern novel in the eighteenth century. He pointed out that in 1740 there were 10 new novels a year in Germany, by 1770 this had risen to 100 and that by 1800 there were some 500 new novels each year (17):

This appears to us what is the particular and new in the narration of Cervantes, Fielding and Wieland: that a much more personal narrator emerges as intermediary, whose being is many sided; that the narrated story is placed in multiple perspectives and that the language thereby becomes buried; that the reader becomes drawn in and must remain attentive in order to grasp the buried meaning, such that notwithstanding all the surprises that the narrator allows himself with the reader, given a belief in nature, there is achieved a commonality of indication and considerate evaluation on both sides.359

Kayser argued that the crisis of the modern novel lay therein that this notion of a personal narrator had died, “as if the opacity of the world had become so strong and the question of meaning so unsolvable, that it was impossible to gain a proper survey through a more distant standpoint (namely that of the epic narrator).”360 It was as if it was only when the reader was drawn into the uncertainties of life that reality could be achieved.

Other authors have explored an eighteenth century trend towards various literary viewpoints. Langen (1934), related the problem of viewpoints (Anschauungsformen) to different frames of reference (Rahmenschau) which evolved in late eighteenth century rationalism. Kurth-Voigt (1965), explored the use of viewpoints in W. E. Neugebauer’s German Don Quixote (1753), and in a book on Wieland (1974), where she examined both the philosophical (see below p. 166*) and the literary background, noting how Platonic dialogue had, via Cicero and Lucian, affected Erasmus’ Colloquies. Kurth-Voigt pointed to the significance of Erasmus’ Praise of folly, Brandt’s Ship of fools; Pope’s Essay on criticism, the third Earl of Shaftesbury’s Characteristicks of men, manners, opinions, times; the role of the epistolary novels by Richardson and Rousseau. Kurth-Voigt focussed on Wieland’s Don Sylvio (1764), and his Aurora and Cephalus (1765), making a larger claim that the: “omniscient narrator of the seventeenth century Romance is gradually replaced by a more personal, often ironic and even fictive third-person narrator who betrays a subjective point of view and frankly, inadvertently, admits the limits of his insights.”361. Hence the same Wieland who wrote On a passage in Cicero concerning perspective in the works of Greek painters (1840, see above p. 38*), and whom Kayser associated with the rise of a systematic viewpoint crucial for the rise of the novel, was portrayed by Kurth Voigt as undermining that tradition with a subjectivizing trend.

Dargan (1985), explored the relation of narrative perspective to authorial vision in works by Balzac, Louis Lambert (1832), Colonel Chabert (1832) the trilogy, Story of the thirteen (Histoire des treize, 1833-1835), and Eugenie Grandet (1839). In Louis Lambert, the narrator struggled unsuccessfully to integrate various forms of expression (14): “letters, philosophical tenets, and speculation, poetical myth and mimesis.” By contrast the narrator of Colonel Chabert was more forceful in an integrating role (14): “Through a perspective that explores the relationship of many different levels of meaning, the novel explores linguistic ground beyond the mere recognition of the denotative relation of sign
to referent”. The trilogy, according to Dargan addressed “the problem of fragmented perspective; they relate stories in which chronology, or the rearrangement of it, requires obvious and concerted shifting of the narrator’s point of view”. In *Éugénie Grandet*, the interest shifted (16): “away from the gradual resolution of an open conflict, such as Chabert’s personal war against society, towards the drama of discernment, through the narrator’s eyes, of hidden conflict, passion and the silent depths of experience”.

This emphasis on the subjective impressions of an individual was taken much further by James (1889), who in his letter to Deerfield Summerschool, urged:

> Oh, do something from your own point of view....Any point of view is interesting that is a direct impression of life. You each have an impression colored by your individual conditions; make that into a picture framed by your own personal wisdom, your glimpse of the American world. I don’t think I really do know what you mean by materializing tendencies any more than I should by spiritualizing or etherealizing. There are no tendencies worth anything but to see the actual or the imaginative, which is just as visible, and to paint it.\(^{362}\)

As Spencer (1971), pointed out, James and other great novelists of the late nineteenth century such as Flaubert, Turgenev and Conrad heightened the illusion of the novel as a closed entity by removing the overt presence of the author (55): “to give the impression of autonomous characters involved in dramatic, as opposed to narrated actions”. The ways in which illusions of reality in a novel could be heightened by various narrative approaches were explored by Henry James in his prefaces to the New York edition of his works (1907-1909). These ideas were systematized and analysed in terms of technical possibilities by Lubbock, in *The craft of fiction* (1921), who claimed that: “The whole intricate question of method, in the craft of fiction, I take to be governed by the question of point of view -the question of the relation in which the narrator stands to the story”.

Lubbock, using an inductive approach, described this relation as a dichotomy of telling (picture) and showing (drama), within which there was a spectrum of four possibilities that ranged from panoramic survey and dramatized narrator to dramatized mind and scenic narration. Rather than being concerned with the character’s viewpoints in a novel, Lubbock’s attention was focussed on the relationship between narrator and material and this focus has continued to dominate the way point of view is used by various authors such as Dorothy Richardson, James Joyce, Virginia Woolf and William Faulkner, who developed these techniques of changing perspective by limiting, expanding or contrasting viewpoints. Critics who have further explored these themes include Shipley’s *Dictionary* (1943); Carolyn Gordon and Alan Tate, in *The house of fiction* (1950), Leon Edel, in *The modern psychological novel* (1959), and Wayne C. Booth, in *The rhetoric of fiction* (1961). They use point of view as a basic tool of formal analysis in Anglo-American criticism. Pouillon (1947), in *Time and the novel*, also developed his vision theory which was one of the starting points for Lämmerts (1955, 70-73, 87 ff.), discussion of these themes in his *Building forms of narrative*, who significantly devoted only a few pages to the subject.

Ortega y Gasset, in his essay *On point of view of the arts* (1947, English 1949), described history as an elaboration of cinema and argued that what moved or changed in painting was point of view; that the history of European painting could be seen as a shift from
proximate to distant vision or as “a retraction from the object towards the subject, the painter” and hence painting (826): “which begins with Giotto as painting of bulk, turns into painting of hollow space”. In this development he outlined seven stages: the Quattrocento, Renaissance, Transition, Chiaroscurists, Velazquez, Impressionism and Cubism. In this he saw a distinct evolution (834): “First things are painted; then sensations, finally ideas. This means that in the beginning the artist’s attention was fixed on external reality; then on the subjective; finally on the intrasubjective”. Ortega y Gasset claimed that there was a strange parallelism in philosophy from the nominalists at the time of Giotto who believed in the reality of individual substances; then Descartes, with his emphasis on space; Leibniz with his monadic concept of viewpoints, and finally Husserl’s intersubjective realities of phenomenalism. His aim was primarily to draw attention to these striking parallels between art and philosophy and raise the question of where one could go from here. In another of his fundamental essays On the dehumanization of art (1947), Ortega y Gasset, drew attention to a problem that had also concerned Panofksy in a different context (see p. 239*), namely the objectification of the subjective:

if, in turning our back on alleged reality, we take the ideas for what they are -mere subjective patterns- and make them live as such...then we have dehumanized and, as it were, derealized them. For ideas are really unreal. To regard them as reality is an idealization, a candid falsification. On the other hand, making them live in their very unreality is, -let us express it in this way- realizing the unreal as such. In this way we do not move from the mind to the world. On the contrary, we give three-dimensional being to mere patterns, we objectify the subjective, we worldify the immanent.363

Type    Description     Author
1.history of books  any catalogue of writers or books  Cave
2.intellectual history  jurisprudence,mathematics,philosophy  Bacon
3.history of nationalism tracing of national spirit,ideals  Schlegel
4.sociological method  political,social, economic causes  Marxists
5.historical relativism enter into mind of past age  Meinecke, Craig
6.internal history  internal development in isolation  Grierson

Fig. 40. Six types of literary history outlined by Wellek (1946,113).

Wellek (1946), listed six types of literary history (fig. 40) and saw a need to avoid both false relativism and absolutism. For our purposes, this list is the more interesting because some of the categories clearly relate to methodological debates in other fields. For instance, five and six relate to debates of vertical and horizontal history among historians and debates of external vs. internal history among historians of science, who are also discovering the attractions of alternative four. Wellek’s solution was to adopt Ortega y Gasset’s concept of perspectivism (121): “we must be able to refer a work of art to the values of its own time and of all the periods subsequent to its own, convinced as we are that a work of art is both ‘eternal’ (that is preserves a certain identity) and ‘historical’ (that is passes through a process of development which can be traced)”. This approach was developed by Wellek and Warren (1949), in their Theory of Literature, and formed a point of departure for Guillen (1968, 1971), whose deeply
learned and subtle essay related historical developments in art and philosophy with those of literature. Spencer’s (1971), *Space, Time and Structure in the Modern Novel*, was another early attempt in English at synthesis on this topic. Spencer distinguished between closed and open structures. In a closed structure (26): “only one perspective is permitted as a point of view upon the subject”, which gives the novel intensity and autonomy, there is often an emphasis on the extraordinary, characters may be ruthlessly subordinated to a theme. Open structures (52): “embody multiple perspectives, some of which are actually contradictory, whose purpose is to expose the subject from as many angles as possible—ideally, with an impression of simultaneity”. Spencer went on to discuss perspectives of the architectonic novel; perspective and narrative point of view; perspectives of the camera and perspectives provided by the book itself.

In Hungary, Lukacs, a professor of aesthetics, gave perspective rather different meanings, claiming that it was characterized by three qualities:

First, something is described as a perspective by the fact that it does not yet exist. Were it to exist it would not be a perspective for the world which we create. Secondly, this perspective is not, however, a mere utopia, but rather...the necessary consequence of an objective societal development, which expresses itself objectively in poetic form in the development of a series of characters in given situations, and third: it is objective, but not fatalistic...it is the tendency in reality towards actualisation...through deeds and handlings.364

Perspectivism, in this sense is "directed towards the future" or a "plan for the future," a meaning which arose in the early nineteenth century, but which subsequently became particularly popular in communist countries in Eastern Europe. In Western Europe, attempts at systematization evolved to alarming complexity. Lubbock (1921), was clearly a starting point for Stanzel’s (1955), basic dichotomy between telling (berichtend, panoramatisch) and showing (darstellend, mimetisch), and probably for his three basic categories: authorial narrative situation (autorkiale Erzählsituation), I-narrative situation (Ich-Erzählsituation) and personal narrative situation (personale Erzählsituation).

Friedman (1955, 1975), also began with Lubbock’s basic distinction between telling and showing which he then spanned with a spectrum of eight possibilities: editorial omniscience, I as witness, I as protagonist, multiple selective omniscience, selective omniscience, dramatic mode and camera. Dolozel (1967, 1973), according to Lintvelt, began with two basic narrative forms, the He-Form and the I form each of which was subdivided into objective, rhetorical and subjective to produce six basic categories of narrative, namely, three pertaining to the He form: objective, rhetorical, subjective and three pertaining to the I form: objective (i.e. of the observer), rhetorical, subjective (i.e. personal).

Meanwhile, according to Lindemann (1987), Dolozel actually had eight categories.: first person active narrator; first person passive narrator; first person passive character; first person active character; third person active narrator; third person active character; third person passive character; third person passive narrator. An important article in French on “Point of view or narrative perspective”, by Van Ressum-Guyon (1970), provided a survey of these developments.
Leibfried (1970, 1972), used a combinatorial play of narrative characteristics. He started with two basic concepts: perspective narrative and grammatical form. Perspective narrative he defined as either internal, when the narrator participates in the action; or external, when the narrator plays no role in the story. Grammatical form was divided into a first person, I form (Ich-Form), and a third person He form (Er-Form). These were then combined to produce four alternatives: internal perspective with I form, internal perspective with He form, external perspective with I Form, and external perspective with He form. Füger (1972), used a similar combinatorial method with three basic categories: narrative position, depth of the perspective narrative and grammatical form. Narrative position he divided into external narrative position and internal narrative position. Depth of the perspective narrative was defined whether the centre of orientation had superior knowledge, adequate knowledge or inferior knowledge. In grammatical form he defined the first person (Ich-Form) and second person (Du-Form) as personal and the third person as impersonal (Er-Form). These were then combined to produce twelve alternatives (fig. 41).

<table>
<thead>
<tr>
<th>External Position</th>
<th>Superior Knowledge</th>
<th>Personal grammatical form</th>
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<tr>
<td></td>
<td>Adequate Knowledge</td>
<td>Personal Impersonal &quot;</td>
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<td></td>
<td>Inferior Knowledge</td>
<td>Personal Impersonal &quot;</td>
</tr>
<tr>
<td>Internal Position</td>
<td>Superior Knowledge</td>
<td>Personal Impersonal &quot;</td>
</tr>
<tr>
<td></td>
<td>Adequate Knowledge</td>
<td>Personal Impersonal &quot;</td>
</tr>
<tr>
<td></td>
<td>Inferior Knowledge</td>
<td>Personal Impersonal &quot;</td>
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Fig. 41. Twelve combinations of perspectival structure from Füger (1972).

In Russia, inspired partly by Bakhtin, Uspensky, (1966, English translation 1970), published his *Poetics of composition. The structure of the artistic text and typology of a compositional form.* Uspensky identified four planes on which point of view could be analysed: ideological, phraseological, psychological, and spatial-temporal. The ideological plane he also called evaluative (8): “understanding by evaluation a general system for viewing the world conceptually”. He described the phraseological level in terms of naming; correlation between the speech of the author and the speech of the characters in the text; the influence of someone else’s speech on authorial speech; the influence of authorial speech on someone else’s speech; internal and external authorial positions. In the spatial-temporal plane he considered the concurrence and non-concurrence of the spatial position of the narrator and a character; the sequential survey, bird’s eye view and silent scene. In terms of time he outlined multiple temporal positions as well as tense and aspect and the temporal position of the author. On the psychological plane Uspensky returned to his earlier distinction between internal and external to identify four different cases of authorial position in narration: 1) unchanging and consistently external; 2) unchanging and consistently internal; 3) changing in sequence; 4) changing with simultaneous use of different positions.

Pfister (1974), whose important work on perspectival structures in Elizabethan plays has already been cited above, offered a concise summary of the various meanings of perspective among literary theorists:
The concept of perspective is used in the jargon of literary criticism as often and usually as imprecisely as the concept of structure. Both reveal themselves to be highly polyvalent in meaning and constantly require, if they are not to flow into the uncommitted and general, precision through definition. The concepts perspective and perspectivism appear in the most varied of contexts and with the most diverse of meanings. In the theory of literary history perspectivism refers to a scientific position which is as far removed from historical relativism as it is from unhistorical doctrinaire absolutism. In Marxist literary theory perspective refers to the progressive, anticipatory direction of works of socialist realism and frequently perspective is also merely used as a vague metaphor for a given viewpoint or interpretative approach, from which a work or a group of works is considered. Nonetheless, in the recent theory of the novel the concept of perspective has evolved to a generally acknowledged category of analysis of high heuristic value.

Lanser (1981), developed a much more complex typology consisting of three basic elements: status, contact and stance. Status used Plato’s basic distinction between diegetic and mimetic as its starting point. Contact involved mode, attitude and identity of narratee. Stance subsumed Uspensky’s four planes: phraseological, spatial-temporal, psychological and ideological. Diegetic authority was then divided into authorization and social identity. Psychological was divided into information, focalization, attitude and expression. Ideological was divided into relation to culture, text and authority. Each of these categories was further subdivided partly on the basis of Chatman’s oppositions. For instance authorization was divided into authorial equivalence; representation (hetero- vs. auto-diegesis); privilege (limited vs. omniscient); reference (report vs. invention). There were thirty one further categories (Appendix 6). The full complexity of Lanser’s system only becomes apparent when it is realized that each of the basic oppositions can in turn be subdivided into an entire spectrum of distinctions. Hence, the opposition heterodeigenesis-autodiegenesis can be further subdivided into six variants: uninvolved narrator (no place in the story world); uninvolved eyewitness; witness participator; minor character; co-protagonist; sole protagonist.

Lintvelt (1981), reviewed the majority of these developments and produced the most complex system to date. He began with a distinction between cases where the narrator does not enter into the story (narration heterodiégétique) and those in which the narrator is also the actor of the story (narration homodiégétique). The first of these he subdivided into three categories: authorial, actorial and neuter; the second of these he subdivided into authorial and actorial thus producing five basic categories. Each of these was then analysed in terms of four planes, namely, perceptual-psychic, temporal, spatial and verbal and further subdivided to create a system of labyrinthine complexity (Appendix 7).

Lindemann (1987), surveyed these developments and produced a chart to make visible common aspects among various authors (Appendix 8). He also noted that this great proliferation of terms and methods had actually focussed on a relatively small section of potential literary experience, which he sought to clarify by a concept of three worlds, reality, fiction and represented world, arguing that literature was ultimately about all the relations in all three worlds and not just about fictive narrators and listeners (fig. 39).
Implicit in these attempts at systematization, was an assumption that one could catalogue and classify the viewpoint of an individual. Kayser (1954), had argued that the disappearance of a clear narrative viewpoint signalled a crisis in the modern novel, intimating that the very concept of the individual was at stake. Guillen (1971), who saw the same problem, was more careful and raised the question what might happen next.

One development has been increasing attention to multiple viewpoints using a variety of terms. Mandelkow (1960), and Kimpel (1967), referred to polyperspective. Stanzel (1964), in his *Typical forms of the novel*, spoke both of multiperspectival, and multiple perspective. Lange (1965), preferred many-perspectival; while Schmidt-Henkel (1965), used polyperspectivism. Neuhaus (1971), attempted to classify these developments in his *Types of multiperspectival narrative*.

The rise of cinema has obviously played its part in the development of interest in multiple perspectives. We noted that Ortega y Gasset used the image of film to characterize developments in literary point of view. Spencer (1971), claimed that John Dos Passos “was among the first novelists to understand how the simulation of the camera could extend the range of the novel’s perspectives”; that his trilogy, *U.S.A: The 42nd Parallel; Nineteen nineteen and the big money* (1930), employed two perspectives which were prose approximations of camera techniques, namely, the newsreel and the camera eye.

Eisenstein (1957), claimed that “Language is much closer to film than to painting”; that montage is the structural principle of all the arts and took a radical position in a debate about the nature of montage, arguing that the participating elements should be varied “so that their combination provides contrast, conflict, tension and explosion”, whereas others insisted that these elements should be similar to one another such that their ensemble resulted in an impression of harmony.

Under the heading viewpoint, in the *Dictionary of world literary terms*, Shipley (1955), reported that critics see this concept as governing the method and character of a work. He distinguished between internal and external viewpoints and identified three kinds of internal viewpoint: where the story is told by the leading actor, a pretended autobiography; a first person story, which is told by a minor character or where the story is told by several characters, each taking a different part in the adventure. This he contrasted with the external or Olympian point of view in which a superior narrator views all the characters from an equal distance. The advantages and disadvantages of both methods were outlined and mention made of an alternative where a shifting viewpoint is used.

While some authors, such as Guillen (1968), described Robbe-Grillet (1959, 1964), as (355): “one of the first important writers who has tried to separate seeing from knowing”, Spencer (1971), claimed that (107-108): “since his novels actually evolve from a blended perspective that combines the subjective human view of the novelist with the objective,
non-human view of the camera, his works provide some of the best available examples of how the novel may expand its powers by using the perspectives of the camera”. The tremendous literary possibilities of cinema were very vividly described by Monique Nathan (1958):

Refusing all interpretative commentary, it [the novel] ought not to give one something to think about, but something to see. It exposes reality at a glance; it multiplies points of view; it varies appearances; it unmasks what no one sees, the underside, the upperside, the horizontal and the vertical, the inside and the outside, making the distant seem near-at hand and the near seem distant; it amplifies, in a word, all the variations of incident and the limited distances of the human visual field, and in so doing it amplifies the apprehension of the real.370

Hönnighausen (1976), saw the emergence of multiple viewpoints as part of a larger shift in philosophy and world views. He argued that this could be traced to the end of the nineteenth century which introduced a new positive view towards both lying and masks in the writings of Oscar Wilde and Friedrich Nietzsche. The demise of first person discourse and authorial narrative generally, which Kayser had bewailed, was now linked to the development of various narrative masks in James and related to the rise of relativistic criticism. James’ contemporary, Walter Pater, for instance, had asserted that: “the aim of right criticism is to place Winckelmann in an intellectual perspective of which Goethe is the foreground”. Matthew Arnold and H. A. Taine had made similar assertions.

Hönnighausen argued that this nexus of developments went much deeper; that it was bound up with tendencies to separate the sphere of art from the sphere of ethics; that the suppression of the narrator was linked with developments in criticism such as T.S. Eliot’s (1917), Tradition and the individual talent, whereby: “Poetry is not a turning loose of emotion, but an escape from emotion; it is not the expression of personality, but an escape from personality”371; which according to Hönnighausen led to the New Criticism and its ahistorical approach to aesthetics. He claimed that in terms of literature the suppression of the narrator was linked with the emergence of multiple personalities in literature as in Stevenson’s, Dr. Jeckyll and Mr. Hyde, and Wilde’s, Picture of Dorian Gray, to whom “man was a being with myriad lives and myriad sensations, a complex multiform creature that bore within itself strange legacies of thought and passion”; which, claimed Hönnighausen, was ultimately the source of Pound’s Personae; concepts of transformation and cloaking in Barth’s (1960), Sot weed factor, and the impersonations in Pynchons’ V (1963).

This fascination with masks should perhaps be linked with a growing attention to the experience of circus in semiotics; where students have become increasingly uncertain about where reality lies: on stage, where the circus members are clearly acting; off-stage when they are consciously letting themselves be interviewed and playing the part of circus performers; or in their everyday life when the magic of their profession is least in evidence. Masks have also become an increasingly dominant theme in the cinema with films such as Darkman and the Invisible Man.

Meanwhile, Nathalie Sarraute (1956), took further the approach of multiple viewpoints with her technique of sub-conversation (sous-conversation) intended to explore: “the
region of awareness that is conscious but consists of thoughts that have not yet been censored, edited, trimmed, or made respectable enough for use in actual speech—\(^{372}\)—a method which sounds suspiciously like the subsequent quests for sub-texts à la Derrida. In any case, these developments confirm that if the repression of a dominant narrator in modern literature involves the demise of a particular kind of static individualism, it appears also to herald new dynamic, polyvalent forms of individualism. Persons who answer calls on the cellular telephones while driving along highways in their automobiles or write reports on computer screens while flying in a jet, cannot be described with the same frameworks as a person who was born, lived and died on the same farm. In the most advanced technological societies these modes of communication are changing so fast that our rules of interaction, e.g. answering machines and even our concepts of sincerity are constantly being revised and we lack models because the rules keep changing.

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<thead>
<tr>
<th>Author</th>
<th>Works</th>
<th>Scholar</th>
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<tr>
<td>Balzac</td>
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<td>Dargan (1985)</td>
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<td>Beckett</td>
<td>Endgame, Rockaby</td>
<td>Hale (1987)</td>
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<td>Broch</td>
<td>Death of Virgil</td>
<td>Kristiansen (1977)</td>
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<td>Pickwick Papers</td>
<td>Wickardt (1933)</td>
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<td>Donne</td>
<td>Obsequies</td>
<td>Gilman (1978)</td>
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<td>Fontana</td>
<td>Irrungen Wirrungen</td>
<td>Schmidt-Brümmer (1971)</td>
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<td>Zizn Klima Samgina</td>
<td>Imendörffer (1973)</td>
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<td>Marvell</td>
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<td>Spenser</td>
<td>Fairie Queene</td>
<td>Constance (1976), Kamholtz (1980)</td>
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<td>Storm</td>
<td>Immensee</td>
<td>Sammern-Frankenegg (1976)</td>
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<td>Wieland</td>
<td>Don Sylvio</td>
<td>Kurth-Voigt (1974)</td>
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Fig. 43. Alphabetical list of some authors who have been studied in terms of literary perspective, and their works.

Among those who have studied the use of perspective in modern literature, most scholars have focussed on individual authors and texts beginning with a study by Wickardt (1933), on Dickens. However, it was not until the 1970’s, the very decade that saw a flowering of systematic theories of point of view theory, that this approach became a serious international trend. In English literature there was Ehlers’ (1977), work on Gothic fiction and a decade later, Hale’s (1987), study of perspective in Beckett. In German literature, there were studies by Schmidt-Brümmer (1971), on Fontana; Kurth-Voigt (1974), on Wieland; Sämmern-Frankenegg (1976), on Storm, and Kristiansen (1977), on Broch. In Russian literature, there was Imendörffer (1973), on Gorkij. In French literature, there was Dargan (1985), on Balzac (cf. fig. 43).

A few thinkers have reflected on general issues relating to perspective in modern literature (and art), notably Alewyn (1957), Adorno (1958) and Jeziorkowski (1967). Two authors focussed specifically on space. Bachelard (1958), explored different kinds
of space that attracted and concentrated the poetic imagination, notably, various aspects of the house and hut, drawers, chests, wardrobes, nests, shells and corners; questions of miniature spaces; of intimate immensity and the inherent interplay between outside and inside created by such spaces. McLuhan and Parker (1968), noted that, while Piaget had outlined the development of spatial concepts in children (3): “there has thus far been no guide to the changing spatial experience that adults typically encounter in poetry and painting”. This quest led them to reconsider perspective (13):

Perspective itself is a mode of perception which in its very nature moves towards specialization and fragmentation. It insists on the single point of view (at least in its classical phase) and involves us automatically in a single space. Inasmuch as a three-dimensional space is a concomitant of one dimension in time, we find fragmentation developing in both space and time, and in both poetry and painting. Because of the insistence on single times and single spaces, the possibility of “self-expression” arises. In mannerism, this possibility manifests itself in an insouciant violation of the canons of proportion and color, and a realization of the potential inherent in a variety of visual spaces within a single visual space-fragmentation within set parameters.

In McLuhan’s analysis, this perspectival space, which he also linked with neutral Newtonian space, was replaced by the rise of formal space through both Seurat’s painting and Hopkin’s poetry. Abstract art, he claimed, could be seen as an internalization of visual space (28): “Whereas in the Renaissance it was the encounter with the new pictorial or visual space that created discomfort and dismay, the reverse is true in our time. It is the rediscovery of non-visual, multi-sensuous spaces that bothers and confuses us”. Throughout his book, McLuhan stressed the peculiar characteristics of the visual sense (221): “In cultures that give much less stress to the visual sense, ‘rational’ connectedness exercises much less authority” or (249): “The visual sense alone of all our senses, creates the forms of space and time that are uniform, continuous and connected. Euclidean space is the prerogative of visual and literate man. With the advent of electric circuitry and the instant movement of information, Euclidean space recedes and the non-Euclidean geometries emerge”.

According to McLuhan the electronic age brought a return to a non-visual society, which entailed (250): “the dropping not only of representation but also of the story line. In poetry, in the novel, in the movie, narrative continuity has yielded to thematic variation”. He returned to this theme a few pages later (254): “Visual orientation has simply become irrelevant”.

While many of McLuhan’s claims in terms of the effects of these new technologies have with hindsight acquired a prophetic quality, his fundamental claims about the rejection of the visual sense, representation and narrative in electronic culture are very much open to debate. Even if we accept his analysis (266-267) that television involves tactile rather than visual perception, it is striking how the electronic technologies created new spatial worlds not just on television and computer screens but equally in the cinema. Perspective, which was once a matter of textbooks, has now been integrated into both CAD programs and popular drawing packages. Some of these even allow one to transform a scene from linear to spherical perspective. These technologies also removed
what were once clear boundaries between different media such as photographs, slides, images on a computer screen and printed images. If authors are now reading their texts on computer screens rather than on printed pages, this does not mean that they are less visual. Vision and perspective may have new guises, but they are more central than ever to modern culture.

In the context of philosophy and history of science, we noted that Cassirer (1910), in his *Structure and Function*, traced a shift from an emphasis on substance in antiquity to relations in the early modern period. In the context of the history of literature, Jaap (1980), explored a similar shift in his *Relational meaning (Beziehungssinn. Ein Konzept der Literaturgeschichte)*. Cassirer was one of Jaap’s points of departure, as was Nietzsche’s question: “Is not meaning, that is relational meaning and perspective necessary?” This concept was more complex than it appeared at a first glance (13):

Hence relational meaning involves something completely different than simply speaking of relations. Hence it is not just a losing oneself in anything at will (in relativism), but rather a discursive principle of constituting meaning, which we describe as relational reflection. The meaning that concerns us here is that of literature and history as history of literature. Thus the answer to our questions can be reduced to a shortest formula: the history of literature is the history of relational meaning.

Jaap’s basic claim was that the metaphysical claims for the truth of literature which had been articulated from the time of Aristotle through to the nineteenth century were outmoded and had to be avoided. To achieve this it was not a question of abandoning the history of literature but rather of historicizing them. Visions of the whole were no longer to be sought, instead one needed attention to the parts and the relationships between them. He argued that images of a continuous line of thought and tradition needed to be replaced by a view of historical discontinuities whereby there were important jumps from one period to the next; indeed that the history of literature could be seen as a history of crises in and of meaning. While the notion of truth was to be replaced by a history of images of truth (*Wahrheitsfiguren*), this was not to say that these images were merely random. Their choice was closely linked with rules of logic, ethics and aesthetics. Admittedly, they were interpreted rules, but this interpretation was itself an element and result of a combinatorial process, which changed in the course of history. In Jaap’s view, literature and history were inextricably linked through changing relations or perspectives.

Perron, Gordon and Danesi (1994) argued that commonplaces, in the sense of locus communis, (3):"generally entail a subjectivized perspective that reveals a deeply embedded need to literally externalize the subject's feelings by bringing the interlocutor into the subject's domain of experience." According to the authors (3): "Commonplaces constitute evidence in favor of the view that verbal communication is not a script based, disembodied, information transfer process. SF [situation focusing], like other 'creative' discourse phenomena, leads us to believe, on the contrary, that verbal communication is hardly ever a neutral, information transfer act." They claimed that work in cognitive science by communications engineers and artificial intelligence researchers had (4):

rekindled what is perhaps the oldest debate in philosophy: Is 'meaning'a derivative of individual experience (the experientialist perspective)? or is it 'out there',

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waiting for the innate machinery of the mind to capture and store it independently of bodily processes and individual feelings (the literalist/objectivist perspective)?

In conclusion, the authors suggested that subjectivized commonplaces seemed (7) "to show that ego dynamics are at the basis of human cognition. Like in a novel where the author's feelings and perspective shape the form and contents of the storyline, so too SF is one of the means by which the 'author' of an utterance reveals his or her feelings and perspectives in an artful manner." They noted how their approach differed from that of Lakoff, Langmacher and other experientialists but made no mention of the many authors cited in the foregoing pages. In a world where so much has been written there is an ever greater danger of re-inventing the wheel.

The above all too summary treatment gives some idea of how pervasive has been interest among historians of literature in metaphorical applications of perspective, particularly in terms of viewpoint theory and levels of discourse. To a certain extent this work dovetails directly with work on the history of scenography considered elsewhere (see above p. 108-112*). Even so it is important to note that there is still much more to be known about the complex interplays among perspective and narrative in literature and painting. There is, for instance, a very interesting etymological history that deserves to be written for the figurative use of terms such as prospect, perspective and perspectives in major languages. For our purposes it will be enough merely to outline a few notes in terms of their appearance in book titles. In English, the use of prospect in a political sense emerged shortly after the Restoration in 1664 with a book entitled, A prospect of Hungary and Transylvania, followed by, A prospect of government in Europe (1681), and a Prospect of the state of Ireland (1682). In Germany, there was one seventeenth century title, A Prospect of the entire globe (Prospect des gantzen Erdkreises, 1686). In England, there were at least seven titles in the eighteenth century, and it then died out, although the literal sense, as in A prospect from Malvern Hill (1829) continued. In Italy, by contrast, there were but two eighteenth century titles (1752, 1761), with at least twenty titles in the first half of the nineteenth century (e.g.1802, 1804, 1806, 1808, 1811, 1813 1813 etc.), and a marked decline with only seven titles in the latter half of the century (e.g. 1855,1868,1878,1886 and 1890).

Among the early Italian titles was Angelo Ridolfi’s (1818), Prospect of German literature (Prospetto della letteratura tedesca). In the twentieth century, this image shifted from prospect to perspectives. Hence there were Perspectives of French literature (Prospettive della letteratura francese, 1946), and Perspectives of English literature (1947). One of the earliest uses of perspectives (Prospettive) in Italy was for the name of a journal (1939). During and immediately after the war the term was used in an economic context: Economic perspectives of a new Europe (1940) and Economic perspectives of peace (1945). In the 1950’s perspectives occured in at least 6 titles. In these years the scope of the term increased dramatically. It was applied to pedagogy (1957), culture (1959), sociology (1959), communism (1960), history (1960) and philosophy (1964). So too did the number of titles. From 1960-1963 there were a further eight titles. In 1964 alone there were at least eight more. From the mid 1960’s onwards the metaphor of perspectives was universally applied. How these developments varied in different countries would require a major study in itself.
Just as there are historians of art who claim that perspective died in the twentieth century there are historians of literature who act as if the same applied in their field. So-called Post-Modernists, for example, have been troubled by all attempts at separating subject and object, nature and nurture and have made it part of their agenda to conflate such oppositions. In the process, they deny the validity of individual viewpoints because they are supposedly biased. The Deconstructionists take this approach even further when they emphasize the pitfalls of subjectivity to such an extent that any viewpoint at all seems hopeless.

It may be no coincidence that members of the deconstructionist school (e.g. Liotard, Lacan, Jameson) are committed to a privileging of the now, to the extent that, not only are the historical roots of a subject frequently ignored, but the very term has a negative connotation. To say: “It’s history “ is to dismiss something as “no longer important”, “no longer a threat”, finished, forgettable. Ironically, it is precisely this attitude of emphasizing the ephemeral, the ephemeroptera as Leonard flitily calls them, that this school removes the possibility of having the evidence of other standards by which to weigh and balance the modes and fashions of contemporary subjectivity. In destroying the viewpoints of the past, other viewpoints, they condemn themselves to the subjectivity that they lament in others.

It is instructive that the emerging field of Cultural Studies has not failed to notice some of these dangers. Their basic insight is that even though we admit that a voice is biased and limited this does not mean the voice should not be heard; that it is not significant or perhaps even important. Hence, whereas the deconstructionists are bent on our being so aware of our subjectivity that we dare not say anything, even about the irony that they as deconstructionists are happily carrying on saying what we cannot say; the proponents of cultural studies would argue that being biased is not an insuperable problem as long as we are honest about what this is and as long as we do not stop other persons from expressing their biases freely. Only some members of this school talk about different perspectives. Others use auditory terms rather than visual images, referring to voices (marxist, feminist, queer, black) or more general terms (class, race, gender, generation), instead of viewpoints.

As with the de-constructionists there is a tendency to emphasize the now to the extent that the historical roots of their ideas are frequently overlooked or rather not known. Names such as Adorno, Nietzsche, Hegel and Kant hover amidst philosophical movements as clouds in a mountain range. Some acknowledge roots in the Russian structuralism and the Culturology movement of the 1930’s, the Frankfurt School, Birmingham, the Deconstructionists in Paris (fig. 44) or the Kameritu Centre in Kenya. Some emphasize the role of performance of acts, performative acts, the role of theatre and dance as well as activism, in a critique of traditional scholarship which strives for a certain distance, to be removed from the everyday hurlyburly, in order to achieve a reflective state. Often it is forgotten that this view of scholarship as both reflective and active was espoused by earlier scholars such as Alexander von Humboldt who, along with his colleagues, resigned from the university when a colleague was wrongfully dismissed, led to his re-instatement and thus established the principle of tenure in the 1840’s. Even so one senses that cultural studies could implicitly accept the methods that
have been developed by other branches of literature studying perspective. So a new synthesis could be expected.

Moscow  Futurism (Florenskey, Shegin)
Structuralism (Bakhtin)
Culturology

Prague  Structuralism (Jakobson)

Paris  Annales School (Braudel)
Structuralism (Levi Strauss)
Post Structuralism, De-Constructionism (Foucault, Derrida)
Post-Post Structuralism, Post-Modernism (Lacan, Liotard, Beaudrillard))

N. Haven (Yale)  Structuralism (Bloom)
Psychoanalysis applied to History of Art (Blatt)

Birmingham  Cultural Studies (McNeill)

Fig. 44. One outline of some of the influences leading to Cultural Studies from the 1920’s to the 1990’s.

3. Philosophy

Kurth-Voigt (1974), traced the origins of (pseudo-) metaphorical perspective in the sense of point of view back to the Socratic dialogue made famous by Plato and developed by Lucan. This view was implicitly challenged by both Auerbach (1945), and Polka (198*), who noted that Greek dialogue was fundamentally different from the balanced interplay of two points of view that we associate with modern dialogue. Instead the Socratic method was concerned with a systematic destruction of other persons’ points of view, such that what seemed an open conversation between equals was actually an a priori trap whereby the protagonist gradually eliminated other views and replaced them by a single, closed position. This claim has interesting parallels to the pseudo-perspective of the Greco-Roman art, where a series of positions were conflated together, rather than involving an individual viewpoint.

Nonetheless, it is noteworthy that de Folter traces the concept of reciprocity of perspectives (cf. below p. 05*) has its roots in the Greek sceptical tradition founded by Pyrrho of Elis. Etymologically the word "skepsis" is related to the Greek verb "skeptomai" (to look around, spy, observe) and with the Latin verb "specio" (to see) which underlies the words "perspicere" and "perspectiva" (perspective). According to Giannaras (1969), the Sceptics were the first to recognize the perspectival character of knowledge.374 Hence, de Folter (1983), has claimed that it is no co-incidence that Schutz should deal with the sceptic Carneades of Cyrene, in his Problem of Relevance.375

We would suggest that the developments of the dialogue form as they emerged in scholasticism from the twelfth century onwards might be seen as as a metaphorical version of proto- or empirical perspective. On the surface, the dialogues of Abelard, Peter Lombard and their successors are merely protracted versions of the Socratic technique, where the argument is slowly manoeuvred in favour of one position. On closer study, however, fundamental differences become apparent. Whereas the Greco-Roman tradition effectively produced monologues in the guise of dialogues, mediaeval disputations in
dialogue form gave increasing independence to the interlocutors to the extent that it was not always clear who had actually won. And whereas the purpose of Greek dialogues lay solely in the domination of one position, mediaeval disputations were more concerned with testing the validity and strength of contesting viewpoints without always claiming to know which was ultimately right. This marked a significant step toward the ideal of Oxbridge debating clubs where individuals were trained consciously to defend either side of an argument: where what counted was the consistency of the viewpoint that was developed and it was assumed that this was something that was independent of the individual person, just as in linear perspective it was assumed that if someone else stood at the same viewpoint they would see that which the other person had seen.

If we be right there were parallels between technical and metaphorical developments of perspective, between developments in art and those in literature, philosophy and other fields. Hence the shift from proto-perspectival viewpoints in painting at the time of Giotto to the ever more frequent use of linear perspective in the generations following Brunelleschi, was paralleled by a shift from approximate viewpoints in discourse to the development of conversation as an art in which no single person was meant to dominate the other. Some scholars would of course react strongly against these suggestions, claiming that it was precisely this quest to see parallels between different fields of human endeavour, coupled with a (neo-Hegelian) type of evolutionary reasoning that prepared the way for the totalitarian horrors of the 1930’s. To which we would reply that distinctions clearly need to be maintained between forms of thought and their contents. Inevitability and the fatal side of totalitarianism only enters when these categories are conflated and one destroys all opposing viewpoints. By contrast, our concern is to explore how philosophers increasingly became aware of the need to include other viewpoints as a basic dimension of the search for truth, without necessarily subscribing to the complete relativism of multiculturalists in the contemporary American sense (cf. above p. 8*).

Boehm (1969), has claimed that Witelo’s concept of perspectiva (optics) and Nicholas of Cusa’s paradigmatic figure of triangles marked two important impulses towards perspective in late mediaeval thought and indeed that there were several aspects of Cusa’s metaphysics that were linked with concepts of perspectivity. According to Boehm, the writings of Montaigne were also important philosophical expressions of perspectival ideas in literary form. According to Smith (1981) the mediaeval optical tradition which included Alhazen, Grosseteste, Peckham and Witelo, was linked with theories of knowledge.376

The first systematic demonstration of the general principles of perspective occured in Paris with Desargues (1636), and it is striking that one of the first mentions of perspective in a philosophical context occured in the same city. For Pascal, in the Thoughts (c. 1658-1663, 381; Part 1, art.6, “Feebleness of man”), perspective was limited to art: “if one is too young one does not judge well; if too old, likewise....Thus panels seen from too far and from too close. And there is but one indivisible point which is the true place. The others are too close, too far, too high or too low. Perspective assigns it in the art of painting. But in truth and morals who will assign it?”377
His younger contemporary, La Rochefoucault (1665), in the *Moral Maxims*, observed that: “Men and their affairs have their point of perspective: there are those which one must see from close by to judge, and others of which one never judges so well as when one is far away”\(^{378}\). This idea he pursued in his *Diverse Reflections* (1678): “Just as one needs to maintain distance in order to see objects, one needs to do the same for society: each has its point of view from which it wants to be seen. One is usually right not to wish to be lighted from too nearby and there is scarcely anyone who wishes in everything to let themself be seen as they are”\(^{379}\).

The philosopher, Leibniz (1646-1716), who also wrote on linear perspective, used metaphorical images of perspective throughout his writings. Between 1668 and 1671, he developed the idea: “that the soul is like a mathematical point-i.e. non-extensive - on which all perceptions converge as perspective lines do on a point of view”. In his *Théodicée*, Leibniz (1710), drew on analogies with anamorphosis to claim that apparent disorder in the universe could be corrected by a different viewpoint:

> It is as in those inventions of perspective, where certain beautiful drawings only appear confused until one brings them back to their true point of view and observes them using a certain lens or a mirror. It is in placing them and in using them as one should that they become the ornament of a cabinet. Thus the apparent deformities of our little worlds are united in the beauties of the large world and have nothing which opposes itself to the unity of a principle that is infinitely perfect\(^{380}\).

He also used the example of conic sections to illustrate his principle of how relations between perceiver and perceived could be different and simultaneously truthful:

> Projections of perspective which in the circle come from conic sections, let us see that a same circle can be represented by an ellipse, a parabola and by a hyperbola and even by another circle, a straight line and a point. Nothing appears so different, so unalike as these shapes and yet there is a precise relationship from each point to each point. In like manner one needs to admit that each soul represents the universe according to its own point of view and by a rapport which is proper to it but a perfect harmony always subsists\(^{381}\).

In Leibniz’ (c. 1714), *Monadology*, this individual being became the monad which was also governed by perspective:

> Just as the same city regarded from different sides offers quite different aspects, and thus appears multiplied by the perspective, so also it happens that the infinite multitude of simple substances creates the appearance of as many universes. Yet they are but perspectives of a single universe, varied according to the points of view, which vary in each monad. This is the means of obtaining the greatest possible variety, together with the greatest possible order; in other words, it is the means of obtaining as much perfection as possible. Only by this hypothesis (which I dare to call demonstrated) can the greatness of God be exalted as it ought to be.\(^{382}\)

Hence for Leibniz the infinity of perspectives were a sign both of God’s pre-established harmony and a proof of God’s greatness. Leibniz proved a starting point for a number of
later commentators. One was Litt (1926, see below) who saw Leibniz as a first step towards the ideas of Shaftesbury and Herder. Kaulbach (1968), examined the development of Leibniz’ concept of the standpoint particularly in relation to the idea of subjectivity as independence. Nieraad (1970), studied Leibniz in relation to Standpoint-consciousness and world connections. Schneider (1971), considered “Leibniz’ double standpoint”, one absolute and the domain of God, the other relative and the realm of humans. One of Schneider’s points of departure was how Leibniz treated knowledge (Erkenntnislehre) as a problem of standpoints. The absolute standpoint was a way of understanding the mysteries of religion that pointed to God.

Meanwhile, as Kurth-Voigt (1974), noted (see above p. 155*), the empiricist school was providing more secular incentives for perspective in the sense of viewpoints. Gassendi, citing the ancient philosopher Epicurus, had claimed: “Nothing is in the intellect that was not previously in the sense”, an idea usually associated with the Aristotelian tradition. Locke (1632-1704), developed this approach by emphasizing the role of experience. Since this differed from person to person, it followed implicitly that there were potentially as many viewpoints as there were persons. Locke’s most avid champion in England, Joseph Addison (1672-1719), pursued these ideas in an article on the “Pleasures of the Imagination”: “Our sight is the most perfect and the most delightful of all our senses. It fills the mind with its objects at the greatest distance and continues the longest in action without being tired or satiated with its proper enjoyments”.

Addison’s conclusion that we cannot “have a single image that did not make its first entrance through the sight” was a paraphrase of Epicurus. By implication sight was now a key to both the imagination and different viewpoints. And there was a connection between the sceptical empiricism of Hume (1711-1776), and his subtle treatment of different points of view in the Dialogues concerning natural religion, where the persona was to “deliver the sentiments of sects that naturally form themselves in the world and entertain different ideas of human happiness.” Indeed, Kurth-Voigt (1974), claimed that Hume’s aim was “to have each speaker offer from his point of view the perspective he represents in the complex realm of philosophy”.

It was in Germany, however, where the metaphor of perspective gradually acquired an important role in discussions of method. Johann Martin Chladni (Chladenius, 1710-1759), a professor of church history and later professor of theology at Wittemberg, was one of the first to expressly discuss the metaphor of perspective in terms of systematic method in his Introduction to Correct Explanation of Good Speech and Writing (1742):

Those circumstances of our soul, body and our whole person which make or are the cause that we suppose a thing to be so and not otherwise, we wish to name the see-point (Sehe-Punkt). Namely, just as the position of our eye and in particular, its distance from an object is the cause that we receive such an image and no other, so too is there with all our conceptions, a reason why we should recognize a matter so and not otherwise and this is the see-point of the same matter.

Chladni became an important writer on the theory of history, mainly through his General Science of History (1752), in which he specifically acknowledged Leibniz as one of the early users of the perspective metaphor:
The see-point is the inner and the outer condition of the observer, insomuch as there flows therefrom a given and particular way of looking at and observing the things that came before one. This is a concept that goes together with the most important concepts of the whole of philosophy, but which one is not yet accustomed to employ usefully, except that Leibniz used it here and there in his metaphysics and psychology. However, in historical knowledge almost everything depends upon it.388

Meanwhile, Christian August Crusius (1715-1775), professor of philosophy and theology at Leipzig and Meissen, had explored the perspective metaphor as a way "to explain the difficulties that persons do not sufficiently understand,"389 in his Way to the Certainty and Reliability of Human Knowledge (1747), where he too used the phrase see-point:

Now when persons wish to share such concepts with one another then it is unavoidable that each person in terms of the concepts with which they are already familiar, because of the different approach, needs to see the matter to a certain extent with different eyes and so to speak from a different see-point390

For Crusius, this see-point or viewpoint became synonymous with a method for explanation or interpretation, which arose as he put it: from a comparison of all the circumstances to determine the correct see-point from which the author has seen a matter and place oneself in the thoughts of the same.391

It was particularly through through various strands of the idealist school that this metaphor of perspective was developed in a philosophical context. Kant (1724-1804), in the introductory section to his Critique of judgement (1781), formulated the concept of a ground (Boden), which served as a point of departure for both objective and subjective positions. Hence, when in modern English we speak of the grounds of an argument, we usually refer to the basis for another person’s (often opposing) viewpoint. This idea he developed more explicitly five years later in his essay, What does it mean to orientate oneself in thinking? (October 1786), in which he articulated his notion of a standpoint (Standpunkt).392

Orientation, claimed Kant, begins quite simply with a geographical orientation. In an everyday situation a person looks around to discover where they stand with respect to up and down and the four directions, North, South, East and West. This method of geographical orientation, he claimed, could be extended to dark rooms, i.e. situations where the eye cannot see surrounding objects, but again uses up-down, and the points of the compass to determine where they stand. This idea he developed: “Ultimately I can extend this concept even further such that he would then be in a position not only to orientate himself simply in space, i.e. mathematically, but also in thinking, i.e. logically”. (It is useful to recall that Kant’s essay on orientation in space was one of the starting points for Cassirer’s discussion of space in his Philosophy of Symbolic Forms, 1923-1929, 1955, vol.2, p. 93). Meanwhile, four years later, Kant returned to this problem in his Critique of the Power of Judgment (1790):

Under the common sense one must, however, understand the idea of a social sense, that is a capacity for judgment, which in its reflection takes into account, (a priori) the modes of presentation of every other person, in order to hold one's
view equally concerning the whole of human reason, and thereby to avoid the illusion which arises from subjective, private circumstances that could easily be held as objective and which would have a negative influence on one's judgement. Now this occurs because one's judgement of another person exists not only out of actual but much more out of possible judgements and one puts oneself into the position of the other [person], in order that one can abstract from the limitations which may by chance happen to adhere to our judgement.\textsuperscript{393}

As Blankenburg (1991,3) has noted, Kant's transcendental view, when transposed to the sphere of everyday experience, readily lends itself to the concept of perspectival exchange.\textsuperscript{394} Indeed the notion of putting oneself into the place of another person, "standing in their shoes", has become a basic aspect of modern discussions.

Litt (1926), in his Modern Ethics, noted the contribution of Herder (****) to the metaphor of perspective in philosophy:

When Herder formulated the famous phrase, that each nation had the middlepoint of its own happiness-- and for the disciples of Shaftsbury and Leibniz this coincides with manners, in itself, just as every sphere has its centre of gravity, so he fulfills that which was prepared by Leibniz' concept of the perspectivism of the monadic world view, without being able to be developed within the framework of his system.\textsuperscript{395}

Hegel (1770-1831), in his Phenomenology of the spirit, pursued the idea of a standpoint (Standpunkt). In terms of the standard reference works it is noteworthy that Zedler (1732-) in his Universal lexicon had entries for the terms eye-point (Augen-Punkt), principal point (Haupt-Punkt) and standpoint (Standpunkt), but no figurative meanings for these. Adelung, in his Attempt at a complete grammatical critical dictionary (1774-1781), included figurative uses of viewpoint (Gesichtspunkt) and standpoint (Standpunkt). The brothers Grimm (1897), in their etymological dictionary traced the figurative use of the term viewpoint (Gesichtspunkt) through Leibniz, Gellert, Lessing, and Möser and also used the term horizon (Horizont) figuratively.

According to Ferrator Mora (1958), it was Gustav Teichmüller, a professor of philosophy at the University of Dorpat, who first coined the term perspectivism in The real and the apparent world. A new foundation of metaphysics (1882). Teichmüller was very conscious of giving a new meaning to the traditional term of perspective as becomes clear from the following passage (185):

Now if we stood on the sun, the Copernican world view would be apparent to us. Since we stand on the earth the Ptolemaic version is apparent to us. If we stood on Venus or Jupiter we would on each occasion gain a different perspectival view of the world. The mouse cries when it is caught by the cat. The cat, however, is very happy about it. When the progressive party praises a bill, the conservatives are dismayed and conversely. In short, the view of things is always taken from a given standpoint and is therefore perspectival.

Now we know that our opinions, views or concepts are not the true things themselves, but rather that reality shows itself only in the elements of sense, that is in the so-called, sensations, by means of which something corresponding to the
real things or events is unleashed within us. Hence all opinions or views of real things are only hypotheses used to explain our own situation. As a result the concept of perspective can no longer be used to describe the relation of the real thing as an object to the viewpoint of the subject, since real things do not exist for us until have already used them hypothetically as an explanation of our sensations. It therefore but remains for us to take the multitude of sensations themselves as the object, and explain its composition by the subject as the perspectival image. This more refined definition of perspective will meet with no opposition since such a composition of our sensations brings the reception and view of the real world, which nonetheless is only held to be a perspectival image by all scientific researchers.396

Teichmüller considered the major contending philosophical systems and concluded: “Hence we place idealism in a row with materialism and Spinozism and declare all these world views as perspectival since they allow us to enter into the world view such as it appears from our standpoint”397. His system was remarkable for a number of reasons. One of its points of departure was the concept of being (Sein as well the seiende) in relation to consciousness, themes that Husserl would take up a generation later. Teichmüller drew consciously on Eastern religions, notably Buddhism. He saw his system as based on ontology, from which Nature Philosophy (Naturphilosophie) derived and from which, under the title of phenomenology, the perspectival categories were produced. In this view space, time and motion were perspectival.

Teichmüller’s book was one of the sources of Nietzsche (1844-1900), began with the notion of perspective as visual illusion, and ever changing appearances which led him to assert, in his Joyful wisdom (1882): “It is we who think and feel, who actually and unceasingly make something which did not exist before: the whole eternally increasing world of valuations, colours, weights, perspectives, gradations, affirmations and negations…One must admit this much: there can be no life at all except on the basis of perspectival estimations and appearances”398. Elsewhere in the same book Nietzsche noted:

How far the perspective character of the existence extends or whether it has any character at all, whether an existence without explanation, without sense does not just become nonsense, whether on the other hand, all existence is not essentially an explaining existence-these questions as is right and proper, cannot be determined by the most diligent and severely conscientious analysis and self-examination of the intellect, because in this analysis the human intellect cannot avoid seeing itself in its perspective forms and only in them.399

Nietzsche expressed a similar opinion in *** (1885):” In short we achieve an estimate, also for the not knowing, for the rough and the seeing roughly, the simplified and false, the perspectival.”400 That same year he also referred to “the perspectival, the foundation (Grundbedingung) of all life” in the preface of his Beyond good and evil (1885). In the next three years his ideas slowly clarified. In a fragment written between the end of 1886 and the spring of 1887, Nietzsche claimed: "To the extent that the word knowledge is meaningful, the world is knowable: but its meaning is variable. It has no [inherent] meaning behind it, but countless meanings, perspectivism.”402
In *The genealogy of morals* (1887), Nietzsche restated this idea even more forcefully: "There is only a seeing from a perspective, and the more emotions we express over a thing, the more eyes, different eyes we train on the same thing, the more complete will be our ‘idea’ of that thing, our ‘objectivity’ "403. In the spring of 1888 he went on to claim that there is a "perspective-setting force" from which "every centre of force and not just a person, going out from oneself, constructs the whole of the remaining world."404 As Guillen pointed out, Nietzsche’s perspectivism also went in the direction of pragmatism; that perspectives were vehicles of biological and vital impulses (*Triebe*) which work within the limits and needs of each being: “Perspectivism is only a complex form of specificity. My conception is that each specific body strives in the direction of being master of the complete space and to use his force (his will to power)”405. Hence perspectivism in this sense was much more than a figure of speech or even a personal viewpoint. It related to non-conscious, collective needs and involved what Guillen has termed an ultrapersonal point of view; biologically based and utilitarian in its aim. Meanwhile, Litt, who was critical of trends toward relation in sociology (see p.*** below), offered a brief assessment of Nietzsche's contribution:

That perspectivism of looking at the world and norming of life, in which Nietzsche believed he had found the most sublime expression of the drive to power, does not exclude ideal, fundamental principles of knowledge and formation, but rather includes them. Were it otherwise, then it would not be view and will led formation but rather blind going forth, that would improperly being laying claim to spiritual action.406

The twentieth century saw an enormous rise in the philosophical use of perspective metaphors. For instance, Hartmann (1909), writing *On Method in the History of Philosophy*, claimed that "all factual things first require viewpoints."407

The year 1912 saw the appearance of three significant books on philosophical aspects of perspective by Gehler, Petzoldt and Pollack. The most complex of these was by Gehler entitled, *The apparent image. A philosophical-perspectival study. Apparent world and real world. The foundation of a new critical-philosophical world view. Together with a critical explanation of Kantian criticism*. This was the same Gehler whose debates with Hauck concerning spherical perspective were discussed earlier (p. 123), and indeed a large section of this book continued a polemical attack on Hauck and his followers. Gehler saw his deeper purpose in creating a philosophical approach that improved on Kant. Knowledge, claimed Gehler (137), involved three worlds: an apparent world (*Erscheinungswelt*), the shape of which was certainly recognizable and dependent upon the kind of reception of external stimuli on the organ of vision; a real world (*wirkliche Welt*), which was ultimately unknowable, corresponding to Kant’s thing in itself (*Ding an sich*), the form and position of which was nonetheless most certainly conjectured to exist behind the apparent world and an inner world (*Innenwelt*), the primary and secondary forms of which were normally identical with those of the apparent world. The structure of real space was straight, parallel, endlessly long. This he called geometrical. The structure of apparent space was curved, converging and only went as far as the vault of the heavens. This he called perspectival.
Conscious that this was different from the regular usage, Gehler proposed to call this spherical perspective based on retinal images absolute perspective and refer to traditional linear perspective of painters’ as relative perspective. Gehler cited the work of Schultze to point out that Kant used the concept of space in no less than fifteen ways (fig. 45). Hence while Kant had claimed to deal with space in one sense only, namely, the special space of persons (der spezielle Menschensraum), he had, claimed Gehler, dealt with at least four basic types: apparent space (1, 3, 6, 10 above); what was presumably real space (2, 4); combinations of apparent and real space (7, 8, 9, 12, 13, 14) and impossible space (5, 11, 15).

Gehler noted other problems with Kant’s approach: that his concept of perception was sometimes based on observation of the real world and sometimes of the apparent world. He went on to cite (197) Kant’s fundamental claim in the *Prolegomena*:

The starting point of all true idealists from the time of the Eleatic school until Bishop Berkeley is contained in the formulation: all knowledge through the senses and experience is mere appearance and only in the ideas of pure understanding and reason is truth [found]. The fundamental premise that reigns and determines my idealism is, by contrast: All knowledge of things based on pure understanding or pure reason is nothing other than mere appearance, and only in experience is truth [found].

1) space as it appears to everyman
2) the continuous extension that stretches out in all three dimensions of height, breadth and depth
3) space which each person necessarily puts forward (vorstellt)
4) a three dimensional space which finds its midpoint in every individual and which stretches out from them infinitely
5) an individually determined space that depends on each subject and their view (Anschauung)
6) the space that every person truly sees perspectively; actual appearance which we improve upon with judgement based on experience
7) the sense of space that is corrected by judgment, which first arose through experience and reflection
8) my improved observation (Anschauung)
9) space that represents itself perspectively
10) the fully subjective space determined by the standpoint of the observer
11) the perception of our senses, the errors of which we correct and balance on the basis of experience and the judgement based thereon in our thoughts
12) the subjective perception of space corrected in our thoughts
13) our visual space in which our judgement is continuously and unconsciously active
14) the totality of spatial perceptions that each person naturally has, which are thoroughly individual and subjective.
Fig. 45. Fifteen ways in which Kant used the concept of space according to Gehler (1912).409

<table>
<thead>
<tr>
<th>Kind of Nexus</th>
<th>Cause</th>
<th>Effect</th>
<th>Name of Nexus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completely</td>
<td>Two real objects in opposition</td>
<td>Real object or condition of same</td>
<td>Thoroughly conjectured causal nexus</td>
</tr>
<tr>
<td>partially</td>
<td>One real object and apparent image</td>
<td>Causal nexus of perspectivist standpoint in opposition.</td>
<td></td>
</tr>
<tr>
<td>subjectively</td>
<td>Apparent image and psychic thing in itself</td>
<td>Psychophysical-causal nexus eye (centre of vision) (not conscious seeing)</td>
<td></td>
</tr>
<tr>
<td>subjectively</td>
<td>Psychic thing in itself and understanding (conscious seeing)</td>
<td>Causal nexus of understanding</td>
<td></td>
</tr>
<tr>
<td>subjectively</td>
<td>Our reality and understanding in opposition</td>
<td>Causal nexus of reason</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 46. Five kinds of nexus according to Gehler (1912, 243).410

In Gehler’s view the answer lay not in one or other side of this supposed opposition, but rather in a combination of the two, or in his own terms, in a perfect fit between real object, apparent object and that recognized by the intellect. Gehler went on to chart no less than five different possibilities, describing the kind of nexus involved in each one (fig. 46).

Whether or not we agree with his distinctions, Gehler’s efforts are of considerable interest because they make perspective, in his special sense of the term, fundamental to the process of knowing. Gehler drew upon the work of Helmholtz, Mach, Wundt, and a number of major philosophers and indeed, as we have seen, felt convinced that he had corrected Kant in this matter and that his new critical real-idealism (kritischen Real-Idealismus) would replace Kant’s empirical criticism.

Vaihinger (1911) in his Philosophy of as If explored what he termed fictionalism and noted that "every fiction also contains a seeing of things 'as if they were so'."411 Pollack (1912), in his book on Perspective and Symbol, began with a chapter outlining his “Theory of viewpoints”. He was against a purely relativistic position and wanted to re-establish a positivistic approach. To achieve this he argued that one needed to take relativism as a point of departure. It was not enough to recognize the historical limitations of earlier views: it was necessary to acknowledge the historical limitations of contemporary views. Only by taking this into account could one hope to achieve an enduring approach to knowledge and not fall a prey to American pragmatism against which he warned. Pollack noted that Nietzsche, who had been viewed by many as a peripheral figure, was in fact central to these philosophical questions. Petzoldt (1912), pursued similar ideas in his Problem of the world from the standpoint of relativistic positivism (142): “We can only think of the world from the standpoint from which we truly stand and not from a standpoint from which we cannot think ourselves as standing
or from no viewpoint at all. There is no absolute viewpoint and there is no absence of viewpoint: there are only relative viewpoints”.

Two years later, Ortega Y Gasset, outlined the idea of different perspectives in his Meditations on Don Quixote (1914), with his theory of depth (teoría de la profundidad). This he developed in Truth and perspective (1916), where he insisted that perspectivism permitted one to avoid the twin poles of relativism (there are only individual opinions, hence truth does not exist), and dogmatism (a single body of truth exists, hence individual opinions do not matter). He suggested that: "The personal viewpoint is the only one from which the world, as it truly is, can be observed. Everything else is pretence". He admitted that there were problems with this diversity, and urged: "Yet if, rather than getting angry with one another, we unite our views in a selfless spiritual co-operation, we will build together the stream of reality, just as out of different streams the wide, stately river emerges."

Ortega Y Gasset pursued these problems in The theme of our time (1923) where he claimed: "Perspective is one of the components of reality. It is not its distortion; it is its ordering schema." He saw only one negative kind of perspective: "Just as a landscape has an endless number of perspectives which are all equally true and viable. Only the perspective is false which claims that it is the only one." He was conscious that his approach to perspective was a recent development: "Until today all philosophy was utopian. Each system pretended to be valid for all times and all peoples. The teaching of the standpoint requires, rather, that within a system, the vital perspective from which it stemmed, is expressed clearly."

Kant, in his Critique of pure reason, had insisted that we cannot know things in themselves: “We know nothing more than our mode of perceiving them, which is peculiar to us and which, though not of necessity pertaining to every animated being, is so to the whole race”. Hinton (1888), had noted that: “if our intuition of space is the means whereby we apprehend, then it follows that there may be different intuitions of space.” He was convinced, moreover, that Gauss and Lobachevsky had shown that “we are quite capable of conceiving different kinds of space”. These ideas of Kant and Hinton, combined with the psycho-physical claims of Mach were the starting point for Ouspensky’s (1920), Tertium Organum, in which he related four levels of consciousness with different senses of space and time and corresponding stages of psychology, logic, mathematics, forms of actions, morals, forms of consciousness, forms of knowledge, forms of science, and different beings to create a single metaphysical whole (fig. 47).

1. The sense of one-dimensional space
   The world on the line
   The line as space, everything else as time
   Everything except things lying on this line in motion

2. The sense of two-dimensional space
   The world on the plane
   The plane as space, everything else as time
   Angles and curves as motions

3. The sense of three-dimensional space
   The world in an infinite sphere
The sphere as space, everything else as time
Phenomena as motions. A becoming and changing universe

4. The sense of four dimensional space
Spatial sensation of time

Fig. 47. Four forms of the manifestation of consciousness and their relationship to a sense of space and time according to P. D. Ouspensky.

Meanwhile, Karl Mannheim (1919), explored philosophical and sociological aspects of perspective in his seminal *Ideology and utopia*. One of his basic premises was that value free studies were impossible; that all attempts to identify objective actions were imbued with future intentions in the form of both political goals (ideology) and other dreams (utopia). This led him in the final section to a critique of existing theories of knowledge. It had been generally assumed that the exact sciences, with their emphasis on objectivity and truth, offered a paradigm for all knowledge. This had overlooked the interdependence between truth and social-historical dimensions. In the humanities the origins of a field (*Genesis*) were often necessarily value laden. One needed to recognize the active element in knowledge (*Erkennen*). Moreover he argued that there existed an intrinsic perspectivity of certain kinds of knowledge (255):

In certain areas of historical-social knowledge it is not a defect for a discipline (*Wissenschaft*) to maintain within itself its intrinsic point of view. On the contrary in these fields the possible points of view are intrinsically perspectival and the problem lies not in trying to suppress this perspectivity and to apologize for it, but rather to ask how in the element of this perspectivity, knowledge and objectivity are possible. Similarly, in the case of a visual image of a spatial object, it is hardly a source of error that the essential aspects of this spatial object can only be rendered perspectivally. Hence the problem lies not therein how one could produce a non-perspectival image but rather how one in comparing the different views one can arrive at seeing the perspectival as such and thus arrive at a new kind of objectivity. Hence here again the false ideal of an absolute, removed and impersonal view has to be replaced by the ideal of an intrinsically personal but at the same time constantly unfolding personal view.

Mannheim claimed that there were basically two paths for the theory of knowledge. One could emphasize the importance of normative personal aspects of knowledge (*Seinsverbundenheit*) and insist on point of view (*Standpunkt*), arguing that this continued with the evolution of the social process of knowledge. In which case the accompanying theory of knowledge required revision insomuch that one needed to (258):

“establish the essentially relational structure of human knowledge (in the way that the essential perspectivity of visual objects are accepted without question)”

The second path was that one need not insist on the absolutization of these personal aspects of knowledge (*Seinsverbundenheit*). Indeed the discovery of these personal factors in different viewpoints could mark a first step towards no longer being bound by them: “By adding a point of view indicator to a view that had taken itself as absolute, in a certain sense I neutralise the particularity of the view”. Mannheim did not feel that one could know which of these two paths would be followed in future. In his view, the important fact was that both alternatives spelled the end of naive claims that there existed a sphere of truth per se. In his view, it was significant that in the exact sciences such naive claims
had already been swept away by Heisenberg’s indeterminacy principle. In conclusion, Mannheim mentioned some of the key thinkers who had made possible his new approach to a sociology of knowledge, including Marx, Nietzsche, Freud, Lukacs and Scheler.

Mannheim (1921-1922), pursued these ideas in an important article on “Contributions to the theory of world-view interpretation”, where he outlined a struggle for synthesis, noting seeming tensions between rationalism and irrationalism because fields such as religion and art, although alogical and atheoretical were by no means irrational. Mannheim argued that there were three kinds of meaning (Arten des Sinnes): an objective meaning, an intended meaning and a documentary or characteristic meaning. While acknowledging the problems in arriving at an understanding of a world view, he concluded that the notions of mechanical causality which the humanities had adopted from the methodology of science was being replaced by a methodology that took into account historical world views.

Mannheim (19**), further explored the metaphor of perspective in his Sociology of Knowledge, using as one of his points of departure the analogy between perspective and landscape which Ortega Y Gasset had used earlier:

Landscape as landscape - this is the example by means of which perspectivism is most clearly exemplified- can only present itself perspectivally to a human consciousness and yet a landscape does not dissove into the various possible images of itself, because each of these images is oriented towards something (whence not just any arbitrary image is possible) and because a given perspective, insomuch as it is correct, can also be tested by others. Having, however, conceded this, then history is only visible from history itself. Having accepted that metaphysical knowledge is cultural circle being bound knowledge, then one can only set out from a dynamic system in this sphere of thinking and not accept a unique system of transcendent truths.... However, if one concedes this, then only perspectivism remains possible, whereby the various epochs together become the important periods belonging to it, which as such seem to have an entity of their own, but from the historical observer can only be grasped perspectively -- from positions which only come into being through the process of history.

As noted earlier, Theodor Litt (1926) in his Modern Ethics saw the ideas of Leibniz and Shaftsbury as starting points for the perspectivism of Herder and later Nietzsche. Spranger (1929), in a fundamental article on “The meaning of value free judgements (Voraussetsungslosigkeit) in the humanities (Geisteswissenschaften)” analysed some of the latest developments in philosophy and theology. He recalled that Weber (1919), had expressed the idea of a value free approach to knowledge, but noted that there was a trend whereby world views and value judgements were considered to be at the root of rather than peripheral to the social sciences and the humanities. By way of illustration he cited three recent scholars: Rothacker, Litt and Scheler. Spranger noted that Erich Rothacker’s (1926), Logic and systematics in the humanities, used Dilthey’s three types of world views as a basis for idealized methods in the humanities. Rothacker argued that in order to understand concepts and methods of the humanities fully one needed to trace the roots of the world view on which they were based. As the various perspectives of the
world views changed so too did the effective meaning of the sociological point of departure. Each world view had its methodological consequences and conversely.

Spranger next considered Theodor Litt’s (1928), *Knowledge, education (Bildung) and world view*, claiming that he developed Hegelian objective idealism in keeping with Hegel’s general teaching concerning the unavoidable and fruitful perspectivism of world views by arguing that subjectivity was an inextricable dimension of any research; that the goal in science of trying to remove the subject from the process was disastrous if applied to the humanities. Litt attacked Kant and Weber’s positions concerning the separation of theory and practice, arguing instead that all meaningful thought in the humanities arose from a person deciding for themself, and a venture (*Wagnis*) from the personal perspective of meaning. Spanger also cited Max Scheler’s (1926), *The form of knowledge and society*, who examined a series of definitions of knowledge and criteria for truth, argued that there was no such thing as science for the sake of science and that every branch of knowledge was based on a world view.

Spranger also discussed three factors to demonstrate why the humanities were necessarily dependent on assumptions (*Voraussetzungen*) and perspectives (*Perspektiven*): “1) The humanities are bound to the intellectual (*geistige*) content and form of the particular historical period in which they arise....”424; 2) All understanding in the humanities is bound to the intellectual breadth (capacity) and maturity of the research personality....425; 3) Consciously or unconsciously all understanding comes from the basic position of a world view and only through this origin can it become the basis for ultimate values426.

Spranger saw two possible responses to this perspectivism in the humanities: one, a simple resignation to scepticism, which he decried; a second was to use this fragmentation of scholarly positions as a basis for further development. He noted three trends which made feasible this alternative. First, notwithstanding the different points of departure, entry and various values in the humanities, the underlying law (*Gesetz*) guiding all learning was the idea of truth (*Wahrheit*). Second, although persons in the humanities had various assumptions and values, their quest for truth meant that they were willing to subject these assumptions and values to criticism and revise them as necessary. This distinguished the humanities from simple dogmatism. Third, even if these processes of self-criticism and correction did not eliminate all contradictory points of view, then the intent at finding truth could again guide one towards a synthesis that was not purely relativistic.

Spranger had noted that there were serious dangers in pretending that scholarship in the humanities could be value free when it clearly was not. He ended his article by claiming that the new value bound approach to scholarship was equally if not more dangerous. First, it could lead to a new subjectivism. Second and more serious, there were dangers that individuals attempt to limit universities to one particular world view. He cited the case of Russia and the rising fascism in Germany (in 1929). Or that different world views be relegated to different departments within the university. The challenge he claimed was to insure that thinking and doing remained connected.

Not everyone accepted this new emphasis on perspectivism of viewpoints and world views. In Germany, for example, Heidegger (1927), in *Being and Time*, launched a basic attack on the concept of appearance (*Erscheinung*), and set out to destroy any notion of
perspectivity. Heidegger focussed on the concept of phenomenon, which for him signified “that which shows itself in itself, the manifest”. He noted that it was: “possible for an entity to show itself as something which it is not....This kind of showing itself we call “seeming” (Scheinen)....What appears does not show itself; and anything which thus fails to show itself, is also something which can never seem.” Even so Heidegger’s critique of perspectivism remained largely implicit.

Meanwhile, the phenomenologists were trying to understand these problems in their own terms. Becker (1923), wrote a significant article of “Contributions to the phenomenological foundation of geometry and its physical applications” in which he identified three kinds of space (fig. 48).

1. Pre-spatial (pre or quasi spatial) fields or fields of extension
   a) sensory fields (prespatial fields. First Level)
   b) fields of movement of the organs (prespatial fields. Second level)
2. Orientation space
3. Homogeneous (unlimited) space.

Fig. 48. Three kinds of space according to Becker (1923).

In the United States, Lovejoy (1930), launched an explicit attack on perspective in his Revolt against dualism. He associated the “perspective realists” and the “objective realists” with the scientific positivism of Mach and Petzoldt. In his view cognition was a direct relation between mind and object. A perspective designated certain aspects of an object that entered into a relation of co-presence with the mind. The mind was a focal point for perspectives (cf. the quote by Kant in connection with Gebser below p. 176*). Lovejoy was critical of this process because, he claimed, perspectivity also relied on the position of the percipient which changed from one person to the other (120): “From my point of view the penny may appear elliptical, from yours, circular”. And yet a standpoint implied the existence of something that was not relative. The possibility that if person a who saw the penny as an ellipse could see a circle if he moved to the position of person b who saw it as a circle appears not to have occured to Lovejoy and hence he assumed that viewpoints could at best be a condition not a goal of knowledge and indeed that they led to (123): “a general deliquescence of the notion of factual truth and falsity”.

Notwithstanding such protests, McGilvary (1934), claimed that “in recent philosophy the problem of perspectivity has become of the greatest importance”. For him the concept of a standpoint had become basic to perspective realists (1956,p.1):

The perspective realist makes no claim that he can speak for the universe as it is for itself. He does not consider himself as an outsider looking on, a stranger as it were, from some supernatural realm, passively contemplating a world of nature with whose goings-on he has no active business. On the contrary, he is a natural organism responding to natural stimulations and acquiring thereby such knowledge as nature thereupon puts at his disposal. This knowledge, as far as he can integrate it into a system, is his philosophy. As this knowledge and the integration of it develops, his philosophy develops.... A mature philosophy for him is an ideal never realized. He sees in part, he knows in part, he prophesies in part; and that which is perfect never comes, except as a goal that lies afar off before him.
In contrast to the ever more personal trends in Ortega, George Herbert Mead (1938), introduced an ultrapersonal concept which has had an impact on the concept of perspective-taking (see below p. 205*, 211*):

The perspective is the world in its relationship to the individual and the individual in its relationship to the world. The social individual is already in a perspective which belongs to the community within which his self has arisen....This involves the assumption of the community attitudes where all speak with one voice in the organization of social conduct. The whole process of thinking is the inner conversation going on between the generalized other and the individual.

The French philosopher, Merleau-Ponty also explored the metaphor of perspective in his *Phenomenology of Perception* (1945). He suggested, for instance that one should: "conceive perspectives and point of view as our insertion into the world of individuals."

Elsewhere he spoke of perspective as a way to "slide into the whole world." His concept of perspective was less straightforward than earlier writers as when he claimed that: "The object and the world do not exist except as lived by myself or by subjects such as myself, because they are the sequence of our perspectives, but they transcend all perspectives because this sequence is temporal and unachieved," or when he noted that: "When I look at an horizon it does not make me think of that other landscape that I would see if I were there, nor that one of a third landscape and so on, I do not imagine anything, but all the landscapes are already there in a concordant sequence and the open infinity of their perspectives." Notwithstanding such statements, there are trends in criticism which seek to place Merleau-Ponty into the camp of anti-ocular thinkers (see below p.***).

Hegel, in his *Phenomenology of the Spirit* (), had devoted a fourth chapter to the dialectic of I and the Other. This was one of the starting points for Husserl’s (written c. 1915, published 1973), *Phenomenology of Intersubjectivity*, in which he explored contradictory aspects of points of view that anticipated later developments in perspective taking:

The ‘if I were there I would see myself from there and so I would have this view’ is a contradictory notion. It has a good reason however: that a doubling of the I is possible, just as a doubling of a given real thing, that is, the possibility of two subjects with two bodies becomes clear in this contradictory notion....

Now when, in this way before the actual having of another subject, I can gain a possible notion of it, this indicates how this notion should present itself, how another subject should be given. The exterior representing appearing I is given externally when I see an object which, through its similarity with mine calls for the apperception of an I that is a stranger, that is an I like myself. And that is to say the apperception is precisely such as when, in the sense of that contradictory notion that was made unequivocal, I have not just a simple external appearance of life, but also one that points back to an interior appearance, to the same kind that I would have if I moved there or were there.

Elsewhere Husserl claimed that "through perspectivisation the distancing things constitute themselves." As Diemer has noted, Husserl also used a number of perspectival metaphors in his writings, including shading (*Abschattung*), horizon (*Horizont*), circle of vision (*Gesichtskreis*) and standpoint (*Standpunkt*).
Another reason for his interest in perspective related to his interpretation of historical events in terms of early modern science, which Husserl (1935) explored in *The crisis of European science and transcendental philosophy*. According to Husserl, Renaissance perspective had introduced an antagonism between subjective and mathematical space. Perspective thus vacillated between two seemingly contradictory interpretations: one which had its accent on the eye as a centre of projection and focussed on distortions as in anamorphoses; the other which emphasized the perspectival vanishing point of geometrical-mathematical bodies. The Galilean world view had linked science with mathematical space with the result that one had only objects without perspectival viewpoints. There was no room left for perceptual space. Husserl was concerned with creating a transcendental subjectivity which brought human beings back into the centre of experience, defining the I as a consciousness that enters perspectivally into a polarity between self and object and is thus present in every act. Perspective in this sense thus became linked with the problem of life and presence (*Präsenz*) became one of the reasons for perspectival consciousness, which affected both space and time.

De Folter (1983) explored the reciprocity of perspectives in the work of husserl, claiming that this plays an important role in the intersubjectively identical thing and the intersubjectively identical world. every I is the zero point of an oriented world of appearances, i.e. it is the zero point of a system of co-ordinates from which all things in the world, known and unknown, are observed, ordered and understood. The I is incarnate in the body (Leib), often termed the perceptual body (Wahnehmungsleib) or body of the will (Willensleib) and constantly carries the "here" with it, with respect to which everything else is "there". As perceptual organ the body is bound to a fixed perspective or group of perspectives.

This identity through means of orientation applies both at the level of the solipsistic subject and the intersubjectivity of objects in the object world. As a result: "If I were to take the position of another person and he were to take mine, then his sequences would be the same as I now have them in my position and vice versa." In practice this means I can attain the same but not the identical appearances of the physical environment.

If the world is to be one, in itself with respect to all subjective appearances, and if it is to be possible to express objectively valid truths which can no longer be drawn [back] into the relativism of subjectivity, which every reasonable person must necessarily acknowledge, then there must be conditions of thing determinations which are accessible in the same way to every subject and thereby are necessarily common to all subjects, i.e. which are in principle free from "accidental" subject relations and which, when they belong to one subject belong to all.

Hence, De Folter claimed that for Husserl the true world is a necessary presumption on which he also based his understanding of the reciprocity of perspectives. In his later work Husserl (1950, 1962, 1963, 1966, 1966, 1969, 1973), became concerned with perspective, not in terms of its many viewpoints per se, but rather as a correlative of consciousness, asking the question: how is it that we are able to see an object as identical although its perspectives keep changing? Notwithstanding all this, Husserl has become another philosopher cited by some (see below p. ***) as being in the anti-ocular camp.
Paul, Graf Yorck von Wartenburg, in his *Italian Diary* (1927), saw perspective as a vehicle for the new consciousness of early modern times. He explored how perspective suppressed the pure imaging of early Christian art and increasingly expressed itself in constructions that reflected individual belief and personal expressions of life. Art thus turned away from visible metaphysics towards sensual reality, focussing on realism, effectiveness and actuality (*terribilità*). Yorck examined philosophical connections with nominalism and with the concept of movement and sought thereby to give an explanation for the roots of Renaissance perspective.

Yorck (1956), became convinced that consciousness could only be known through its historical articulation. He claimed that there were three types of historical approach which reflected states of consciousness of self and involved three basic functions experience (*Empfinden*), wishing (*Wollen*) and imagining (*Vorstellen*). Greek culture had emphasized external appearances. Jewish culture had marked an important step towards abstraction. Christian culture marked a final stage in this process (fig. 49).

<table>
<thead>
<tr>
<th>Culture</th>
<th>Function</th>
<th>Characteristics</th>
</tr>
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<tbody>
<tr>
<td>Greeks</td>
<td>Life (<em>Leben</em>)</td>
<td>images, external</td>
</tr>
<tr>
<td>Romans, Jews</td>
<td>Force (<em>Kraft</em>)</td>
<td>no images, more abstraction</td>
</tr>
<tr>
<td>Christians</td>
<td>Will (<em>Wille</em>)</td>
<td>abstraction of hypothesis</td>
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Fig. 49. Basic categories in the philosophical system of Graf Yorck.

In Yorck’s view, Christian values only came into focus in the late mediaeval period and were not articulated clearly until the Renaissance and early modern times. Luther was one expression of this movement: early modern science was another. Science was now a constructive tendency whose postulate lay in the abstractness of hypothesis which seeks to question all visible appearances and to achieve authenticate certainty through the nature of the standpoint.

According to Yorck, the perspectivity of early modern times was a product of Christian transcendental ideas whereby it was believed that the maximally unending God has his reference point in the punctual (in the sense of point-like) self of the person who is therefore put in a position to have this unending God present in his pointed unity. It was no co-incidence that punctuality, again in the sense of point-like, and infinity were also basic characteristics of perspective. Yorck went on to describe what he saw as the scientific implications of these ideas in his *States of Consciousness and History* (1956, 146). In this interpretation Christian concepts led to perspective which in turn generated both virtuality and moment of force as key concepts in early modern thought. As Boehm (1969) put it:

> Perspectival perception vanishes through the infinity of space, which manifests itself as horizon-like merging and in the extension of the horizon. At the same time, however, in the construction of central perspective it wins a vehicle for its realization, whereby the eye point controls space as a constructive structure. The ontological valence of the eye point goes beyond the simple quality of being a point and virtually extends to the entirety of its ‘world’. Thereby the emptiness of
space becomes real, since it is made accessible by the concept of power concentrated in a point as a field of energy. Thereby resistance also becomes real, which as a result of unlimited compositional power was determined as an atom. Meanwhile a very different interpretation of perspective was being developed by the Hungarian Marxist philosopher of aesthetics, Lukács (1956) who claimed that perspective has three characteristics:

first something is characterized as a perspective, insomuch as it does not yet exist. Were it to exist then it would not be a perspective for the world that we are building; secondly, this perspective is, however, not a mere utopia....but, rather...the necessary consequence of a objective social development, which expresses itself objectively in poetical form in the unfolding of a series of characters in given situations and third it is objective, but not fatalistic...; it is... the tendency in reality towards realization through deeds and actions.

This Marxist definition of perspective helps to account for contemporary German usage, which began in the former East Germany, whereby perspective means "directed towards the future" or "a plan for the future." Gebser (written 1947-1948, 1951-1952; expanded 1964-1965), produced a three volume study on the rise and manifestations of aperspectivism in modern culture as a contribution to the development of consciousness. One of Gebser’s points of departure was to focus on concepts of space and time (47): "While the concern of the early Renaissance lay in a concretisation of space, in our period the concern is with time. Our fundamental idea, the quest for a concretisation of time and thereby the realisation and becoming conscious of the fourth dimension, provides us with a means for a comprehensive understanding of our epoch."

Gebser claimed that the advent of perspective in the Renaissance had both positive and negative consequences. On the one hand perspective brought a new consciousness and objectivation of space, which made visible both space and also the person as viewing that space. Hence the same paintings of Giotto and Masaccio which were milestones in the conquest of space were also milestones in the representation of persons as observers and the observed. On the other hand, claimed Gebser, perspective also brought with it limitations the consequences of which continued to affect us, namely, that in order to see or think perspectivally meant seeing and thinking in a fixed way. There were also other consequences, namely that (51): “the unperspectival person (whom one could also call the hearing person) was still primarily auditory, whereas the perspectival person (whom one can also characterize as the seeing person) is primarily optical.” Gebser noted how perspective creates (52): “distance between persons and things. Distance, however, is both a characteristic of the conscious becoming objectivation and of the externalization (Entaüsserung) and liberation of internal conditioning factors that precede and render this possible, which are then found again and realized in the external world.”

Hence, claimed Gebser, perspective had a double characteristic of fixing both the observer and the observed, and to underline this he cited Panofsky: “The history of perspective can be understood both as a triumph of the distancing and objectivizing sense of reality and as a triumph of the distance negating struggle for power or both as a fixing
and systematization of the external world and an extension of the I sphere”. All this served as introduction to Gebser’s programmatic approach to the history of consciousness which, in his view, involved five basic structures, namely, the archaic, magical, mythical, mental, and integral. The general characteristics of each of these were described (83-233), as were their consequences for space and time (fig. 50).

<table>
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<tr>
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<th>Expression</th>
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<td>ambivalent</td>
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<td>the truly perceived</td>
<td>and represented world</td>
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Fig. 50. Gebser’s (1972,368) five structures of consciousness and their consequences.

With each of these five basic structures Gebser associated basic kinds of thinking. Corresponding to the mental was perspectival thinking, which he associated with Leonardo’s visual pyramid and related to J. Stenzel’s pyramidal thinking. By way of explanation Gebser recalled that Plato’s concept of diairesis meant a taking apart or separating, whereby the hitherto finite circle was broken and split into pieces. Aristotle had added to logic an either-or quality and introduced the notion of syllogism as in the case: all men are mortal, Socrates is a man, ergo Socrates is a mortal. This had brought with it a pyramidal structuring of ideas which could be graphically summarized (fig. 51):

Beings

<table>
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<th>mortal</th>
<th>immortal</th>
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</table>

men animals
Fig. 51. Pyramidal thought structures described by Gebser (1973, 354).

Since perspectival thinking had to create its own basis without knowing whether or not it had a sound foundation, it often became a deficient form of logic in cases such as: a human fell into the water. We are all human. Therefore we will all fall into the water. Characteristic of perspectival thinking was that it was simultaneously spatially organizing and spatially bounded as was reflected in its very use of spatial language with verbs such as: presents (stellt vor), shows (beweist), comprehends (erfasst), understands (begreift), grasps (fasst auf), thinks about (überlegt), supposes (unterstellt) and sets apart (setzt auseinander). According to Gebser, Plato’s system had led him to a vertical pyramid of understanding whereby things were lower and higher, arranged in levels.

This Gebser contrasted with Kant’s philosophy where ideas were no longer vertically organized but rather orientation points were positioned in the same plane as himself, using by way of illustration a passage from Kant that had been cited by Leisegang, namely that ideas: “have a valuable and completely necessary regulatory use, namely, that of directing the understanding (Verstand) towards certain goals, in view of which direction lines of all its rules run together to a single point”. Gebser noted how Kant went on to use the image of an horizon, which stood in direct opposition to Plato’s vertical structures. The result of this Kantian triangulation of thought (hence trivalent), claimed Gebser, was that thinking became spatial and static, spirit could be materialized and even time could be spatialized. Gebser did not criticize these trends: he simply warned of their dangers if pushed to their limits, claiming that perspectival thought also led to a necessary mutation in the form of paradoxical thinking. The greater part of his three volume study focussed on the aperspectival world which he summarized in a long series of characteristics (II,491):

- the whole, wholeness, transparency, the spiritual, overcoming of the I, realization of timelessness and timeboundedness, understanding of the concept of time and free time, breaking away from the spatial and systematic; establishment of the dynamic, recognition of the energetic, mastery of movement, the fourth dimension, overcoming of patriarchal system, doing away with ruling and power, increase in intensity, clarity (instead of merely being awake) and a shift in creative points of departure.

A very short article by Santucci (1957-1958), in the *Enciclopedia filosofica*, identified perspectivism (prospettivismo) as a relativistic solution offered by Spengler, Ortega y Gasset and Mannheim, in response to a crisis in contemporary historicism introduced by Dilthey.

Ströker (1958-1959), one of the editors of Heidegger, wrote a thought provoking article on *Perspective in the figurative arts. Search for a philosophical explanation*, in which the author took a phenomenological approach. Spatial perception was explored as a specific relation between a subject and the world, it being claimed that there were links between intentional consciousness and spatial structure. A starting point of this analysis was that in a perspectival view one never discovers the entire object in a single view. One only sees it form a given side. This the author claimed had important implications (152):
For in the concept of the side there lies the idea that the object as a whole is comprehended, (miterfasst in Husserl’s sense of Miterfassung), in its all-sidedness. Such a conception states, namely that I do not simply see figures but rather that I perceive the sides that belong to the thing. And it is this approach alone which motivates my movement be it my own or that of the thing. For I await from such a movement a glimpse of the back side. Things which were merely seen would have none of these effects.

This is to say nothing other than that in spatial perception it is not merely the eye that is at work in its sense function, although this, as we shall presently explain, comprises a decisive sensorial constitutive moment of the thing, but rather that each individual aspect is borne by a categorical, unity giving moment, whereby the various (intentional) contents of the single viewer are bound under the unity of a scene. My perspectival spatial perception is from the outset borne by the conception of a thing that is identical in the midst of its changing aspects. As such it is saved from falling into merely separate individual perceptions and lets the perception of the thing be what it is, namely a perspectival one446.

Ströker recognized that this conscious looking at objects from different sides, while necessary, was not a sufficient condition for perspective. Another important step, claimed the author, came with the shift from perceptual space (Anschauungsraum) to visual space (Sehraum), which brought a new level of abstraction because it required suppressing all perceptual knowledge of the unseen sides and focussing attention on visible aspects of an object. This led to new emphasis on appearance (Schein in Kant’s sense) and helped ultimately, so the author, in the representation of space on a plane. Within this framework the author sketched a brief history of spatial representation from early paleolithic time through Antiquity to the Renaissance. As one context for understanding the conditions for focussing on and representing visible evidence of objects, that is, the background to Greek art, Ströker’s essay was very useful. It was less illuminating in explaining precisely how one shifted from this Greek notion of appearances to the mathematical space of the Renaissance.

According to Jones (1985), the notion of seeing aspects and world views played a particular role in Wittgenstein’s philosophy. Already in his Diaries 1914-1916 (1960) he drew attention to the different ways of seeing anamorphic pictures (Vexierbilder) and relationships (Sachverhalten). Wittgenstein (1960), in his Philosophical researches used the ambiguities of a Necker cube to illustrate these problems. Jones argued that there was a basic continuity in Wittgenstein’s philosophy and focussed on four problems. One was the question of seeing the world properly which, he claimed, was a leitmotif in the Tractatus logicophilosophicus (1960). Another was a trend in the late philosophy towards an overview (Übersichtlichkeit). A third was a fascination with the noticing of aspects. This was touched upon in his Brown book, and formed an important theme in his Philosophical observations (1964), where he used both the duck-rabbit figure and an anamorphic picture by way of example. Finally, Jones, noted the problem of the world view and the whole question of how a way of seeing is established.

Graumann in an important book on the Foundations of a Phenomenology and Psychology of Perspectivity (1960) focussed attention on perspectivity as opposed to perspective, a
This assumption, that makes all looking through to looking ahead and in the
determination of the representation in central perspective is typically fixed,
reveals perspectivity as a time-spatial directional whole, in which the here and
now of my standpoint and the being-here of my perception in things with a
horizontal direction always already implies the then of an immediately following
perception.447

Philosophy and art in the early modern period. On the one hand, Boehm was intrigued
by the way in which early modern thought conceived of truth as certitude, evidence and
clarity using a metaphysical style of evidence based on categories from perspective,
namely, standpoint, horizon, and evidence. On the other hand, he was conscious that
perspective belonged to the sunken concepts that had been set free by the attitude of
world view philosophy that grew from Hegel’s ideas. Boehm began with sections on
perspective 1) perspective theory, 2) pictures, 3) artwork and 4) the problem of the world.
A fifth section drew attention to the twofold meaning of perspective: one focussed on the
object (e.g. Galileo), the other on the concept of self. Montaigne’s views were examinend
in this regard. The final sections of the book examined the philosophical contributions of
Husserl, Heidegger, Nicholas of Cusa and Descartes respectively.

Wartofsky (1978), extending ideas of Goodman argued that the theory of perceptual
constancy was based on Euclidean geometrical optics which, in his view, was false, as
was the belief that the rules of linear perspective were the norm for fidelity in pictorial
representation. His claim was (34): “that we see the visual world as a picture because we
picture it in certain ways. And therefore, what we see becomes, in significant part, a
function of our modes of picturing. Since these modes change, historically and culturally,
so too does our mode of visual perception itself”.

Zeil Fahlbusch (1983), examined Perspectivity and decentralization in connection with
Piaget’s genetic theories of knowledge, which appeared in the series, Studies in
anthropology (vol.6). Piaget was concerned with perspective strictly in terms of spatial
perception and representation (see below p. 197*). Zeil-Fahlbusch used the term
perspectivity in quite a different sense, namely: “everything that does not fit into the
structure of identity or generality, which does not permit hierachisation, which always
remains the particular in the general”448. Her distinction between perspectivity and
decentralizing (Dezentrierung) attempted to confront the special (das Besondere) with
the general (das Allgemeine) and to this extent was a modern reformulation of the
mediaeval debate concerning universals and particulars. According to Zeil-Fahlbusch
however these two concepts were interdependent (15):

The acceptance of a dialectic between perspectivity and decentralization would
have as a consequence for the theory of truth not only that it is an open not
closeable process, as one of the particular interpretations of the genetic theory of
knowledge still seemed to suggest, but rather that truth is not unequivocal
(uneindeutig). Knowledge and decision would be inseparable. And in terms of
one’s conception of humanity this would have the further consequence that this
remains bound to a concrete communication historically and in the present, if we wish to retain a general notion of a reasonable (vernünftigen) person and humane interaction in a community.

Zeil-Fahlbusch claimed that in terms of method this implied that questions of structure had to be brought back to the concrete practice of everyday life in order to that concepts of knowledge could be linked with personal knowledge. To achieve this she challenged Piaget’s sharp separation between insight (Einsicht) and knowledge (Erkenntnis).

The book was in three parts, beginning with a description of her proposed dialectic between perspective and decentralization outlining its consequences for Piaget’s genetic theory of knowledge. A second part, which examined the foundations of this genetic theory, was followed by an excursus on three themes: Kohlberg’s social theory; Habermas’ concepts of I-identity and moral development, and the relationship between cognitive and analytical psychology. Part three returned to consider in more detail four problems broached in part one: Piaget’s conception of psychology as embryology of reason, the relation of objective truth and practical meaning, the problem of subjectivity and intersubjectivity and understanding knowledge in connection with the question of balance.

Elkins (1995), in a book that dealt with both historical and philosophical aspects of perspective suggested that most of the reductive metaphors of perspective were "polar rather than unary." Some of these are

- subject(ive)/object(ive)
- realism/idealism
- mortality/eternity
- north/south
- individual/collective
- interiority/exteriority
- distance/nearness
- viewer/viewed
- literal/figurative
- unity/infinity
- master/slave
- knowledge/illusion
- present/past
- active/passive
- Aristotle/Pythagoras


Philosophy of Science

Parallel and to a certain extent co-incident with the above discussions in philosophy, metaphors of viewpoints and perspective have been explored in the philosophy and history of science. For example, the English philosopher, Bertrand Russell (1914), in Our Knowledge of the External World outlined a system of perspectives. In his system the personal or the "private world" functioned as a "perceived perspective" and he described "perspective space, whose elements are single perspectives each with its own private space."

Interestingly enough the social psychologist, George Herbert Mead (1934), whose ideas are discussed elsewhere (see below p.***), saw perspective as originating in the realm of physics:

The concept of perspective as something natural... is an unexpected gift of... physics to philosophy. Perspectives are neither distortions of any complete structures nor selections of consciousness from a mass of objects, the reality of
which is to be sought in the noumenal world. They are in their reciprocal influence upon one another the nature that science knows.\textsuperscript{451}

Adjukiewicz (1935, in an article on \textit{The Scientific World Perspective}, developed the theme of how perspectives relate to the history of science and the rise of knowledge in general:

The theoretician of knowledge is prepared not to become an impartial judge in the debate between two world perspectives for the claim to truth. He should not strive to take on this role. Instead he should set himself another task: he should devote his attention to the actual changes of the scientific apparatus of concepts and the corresponding world perspectives, and attempt to determine what are the mechanisms that set this change in motion....The task of such an approach to the history of science provides the found kernel of the humanities' understanding of the de lapmental processes of science.\textsuperscript{452}

L. V. Bertalanffy (1955), one of the fathers of systems science, also argued for the importance of a perspectivistic view: "what traits of reality we grasp in our theoretical system is arbitrary in the epistemological sense, and determined by biological, cultural and probably linguistic factors... the choice of the symbolism we apply and consequently the aspects of the reality we represent, depend on biological and cultural factors.\textsuperscript{453}

Feibelman (1960), in an article on \textit{The Indeterminacy Principle from a New Viewpoint}, espoused his own theory of perspectives:

According to this theory the observer would stand in a given perspective and would remain in the condition of a person standing in this position. Hence the perspective exists whether someone takes it in or not. Perspective makes it possible that the person standing in it, observes a section of the natural world, in that it determines which section he should observe. So perspectives have both an enabling and a limiting character, but not a hindering one. Hence the knowledge gained by perspective would always be partial knowledge, albeit not necessarily false knowledge. Perspective belongs to the object and not to the subject.\textsuperscript{454}

All of this is of the greatest interest because it is popularly assumed that the notion of relativistic viewpoints in world-views was introduced by Thomas Kuhn (1962) in his \textit{Structure of Scientific Revolutions}.\textsuperscript{455} and then developed by others such as Feyerabend (196*)\textsuperscript{456} and Hanson (1971).\textsuperscript{457} In fact the role of these gentlemen was primarily that of bringing to a more public attention a series of ideas which had been developing for several centuries, and maturing throughout most of the twentieth century.

Jammer (1974), in \textit{The Philosophy of Quantum Mechanics}, specifically referred to "historical perspective" in the subtitle thereof and in the body of his work discussed the concept of "perspectivism." To the term perspective, he gave his own particular meaning as "a coordinated collection of measuring instruments either in the sense of reference systems as applied in the theory of relativity by Bohr."\textsuperscript{458}

Putnam (1981), attacked the notion of an externalist perspective and espoused an internalist perspective, claiming: "There is no viewpoint of God of which we know or of which we can usefully imagine, but only the various points of view of actual persons
which allow various interests and motives to be recognized, which serve their descriptions and theories. 459

McGillvary (1956), whose ideas have been mentioned above, had referred to a "meta-scientific realism." 460 Rescher (1984), explored the concept of meta-scientific perspective. He differentiated between cognitive and pragmatic perspectives and argued that the thesis of the unity of the sciences could be seen as the myth of the God's-eye view. 461 Dilworth (1986) offered a more global view of recent historiography on the perspective metaphor in a significant article on The Perspectivist Conception of Science. 462

4. History

As noted earlier (p. **** above), the use of perspective metaphors in historical method has been traced back to Chladni's (1752) General Science of History, but as Koselleck has made us aware it has largely been in the twentieth century that this approach has developed seriously. Hartmann (1909) in his work On Method in the History of Philosophy, noted that all factual things first require viewpoints. 463 Mannheim, in his work of the sociology of knowledge was concerned that although one used perspective in this sense, the "historical existence of contents" would not disappear. 464

The existence and the factual being of the Greeks, for example, does not disappear through the perspectives that have become possible through historical books about it. For both the factual being and the existence of an historical period is indeed given as a thing in itself, which various interpretations circle around equally. That we fix this being in itself is justified by the fact that even when we are unable to grasp this being in itself from any perspective, it nonetheless remains as an instance that can be tested against any arbitrary claims. 465

Hedinger (1960) devoted a chapter to "Perspectivity" in his book on Subjectivity and Historical Science. 466 Bergmann and Pandel (1975) included a chapter on "Time Perspective as a Category of Historical Consciousness" in their book on History and Future. 467 Koselleck, Mommsen and Rüse (1977) in an important anthology of essays on Objectivity and Partiality explored various aspects of perspectivism in historical writing. For instance, Mommsen (1977), in an essay concerning the perspectival character of historical evidence and the problem of partiality, noted that there was the world of difference:

between partiality in the sense of an interpretation of historical developments from the standpoint of a particular party, which hypostasizes the results gained to fundamental claims, which presumably result from the objective historical process itself, or are at least could be deduced from it, and an interpretation of past reality based on a given viewpoint value-laden viewpoints and/or theoretical insights and which remains conscious of its own partiality. 468

Mommsen (1977) went on to note that: "The perspectival character of historical knowledge extends to both the selection and the evaluation of historical data both under the viewpoint of values and with respect to the cognitive, conceptual instruments of the historian." 469
there are almost always three groups of fundamental premises enter into perspectival conceptions, which are the conductors of knowledge guiding interests of the historian and influence the general hypotheses, paradigms or theories in a basic way, namely: 1) a particular interpretation of the being of persons; 2) a particular concept of social change, including the conditions under which this occurs or does not occur, 3) particular expectations concerning the future development of contemporary society at the time irregardless whether these expectations are of an hypothetical or fundamental character.\textsuperscript{470}

In the same book, Koselleck (1977) devoted a chapter to "The Creation of position and Temporality. A Contribution to the historiographical Treatment of the Historical World."\textsuperscript{471} He illustrated his ideas with an interesting diagram (fig. 53):

\begin{center}
\includegraphics{perspective_diagram.png}
\end{center}

\textbf{Fig. 53.} Perspective applied to history from Kosellek (1977, p. 104)

Rüsen (1983) explained that: "an extension of perspectives is a methodically organized procedure in historical thinking wherein standpoints are certainly considered, but are also (argumentatively) related to other standpoints."\textsuperscript{472} Rüsen (1986) spoke of a "synchronizing of progress in knowledge with an extension of perspectives."\textsuperscript{473} Rüsen (1986) in \textit{Reconstruction of the Past} claimed that:

The objectivity of consensus (Lübbe) in the sense of stories though their meanings, persons with different positions, needs and interests in social life can also serve in the understanding of oneself, on the one hand frees the historical
process of understanding in the plurality of different perspective building standpoints and at the same time integrates the plurality of standpoint dependent historical perspectives in the unity of the process of the extension of perspectives.474

5. Ethnology
In the field of biology, von Baer (1828-1837), published a pioneering work On the evolutionary history of animals, in which he articulated a law of recapitulation whereby ontogeny imitates, capitulates phylogeny, i.e., that the embryological development of members of any species repeated the evolution of the genus to which the species belonged. This law, cited by Darwin (1859, chapter 14), in his Origin of species, was one of the sources for parallels between the development of a child and the evolution of primitive man. Darwin’s book inspired attempts to apply the theory of natural selection to art by individuals such as Stolpe, Balfour, March and Charles Read. In sociology (see below p. 205*) Spencer and Romanes called for the same. Synthesizing scholars such as Andree (1878), in his Ethnographic parallels and comparisons, pointed to the need for psychology to understand the underlying patterns of human culture that were emerging. Andree (1887), went on to explore “Drawing among native peoples” (Naturvölkern).

Meanwhile, a larger methodological framework was emerging which linked ethnology, anthropology, sociology, psychology and art. Grosse (1894), in The origins of art (Die Anfänge der Kunst), was among the first to explore a functional relationship between art and culture and called for a scientific approach to a domain traditionally ruled by aesthetics475. Haddon (1894), in The decorative art of British New Guinea, was “perhaps the first book that proposed an all inclusive esthetic of primitive art”476. Haddon (1895), published Evolution in art as illustrated by the life histories of designs.

In England, James Sully (1895) in his Studies of childhood explicitly compared the art of children with that of primitive man, noting that one would find (299) “many interesting points of comparison”, while carefully stating that these parallels were imperfect. In the United States, Baldwin (1895), had no such qualms in his Mental development in the child and the race. He claimed (ix) that it was impossible to have a comprehensive notion concerning intellectual development without a definite position concerning the racial development of consciousness, that great problem of the evolution of the spirit, the problem of Spencer and Romanes. Where Sully was content with general analogies, Baldwin explicitly compared the psychology of the child (ontogenesis) with the psychology of the race (phylogenesis) and insisted more strongly on analogies of evolution. Within three years Baldwin’s (1898), book had appeared in German where its racial overtones were taken even more seriously. Burk (1902), in an article explored “The genetic versus the logical order in drawing”.

Specific interest in the role of perspective in these developments also began in the 1890’s with Passy’s (1891), “Notes on children’s drawings”. Clark (1896-1897), pursued this problem in “The child’s attitude towards perspective problems”. Clark claimed that before the age of seven children did not attempt to represent the position of a book in relation to themselves. At the outset children merely placed various objects of a scene onto the paper without any effort to group them. According to Clark the child
subsequently went through four stages of development. At a first stage they grouped persons and objects of their compositions along a ground-line which was either fictive or roughly drawn. At a second stage one could observe the first efforts at representing the third dimension. At a third stage one could observe attempts to note the relations between the various superimposed planes. At a fourth stage a sense of the third dimension was acquired. The various planes were no longer delimited. They penetrated one another and the child sought to show both persons and objects from all their viewpoints, evolving in all directions.

Kerschensteiner (1905), in *The development of drawing ability in childhood*, proposed three phases of spatial representation: the unsuccessful, the unfinished and the finished spatial representation. Levinstein (1904), further explored these questions in a dissertation, *Studies concerning the drawing of children until their fourteenth year. With parallels from cultural history and ethnology*, which included a sixth chapter on “Cultural and ethnological parallels” and a survey (68) of Karl Lamprecht’s system of cultural changes. The following year, Levinstein (1905), published this in book form as: *Children’s drawings until the age of fourteen. With parallels from pre-history, cultural history and ethnology*, now with an appendix by the cultural historian, Karl Lamprecht.

Psychology played an increasing role in these discussions as witnessed explicitly by Verworn (1906), *The psychology of primitive art*, and implicitly by Verworn (1909), *The origins of art* and Verworn (1914), *Ideoplastic art*. Verworn (1908), made his clearest statement of the ontogenetic-phylogenetic analogy in an article on “Children’s art and pre-history”. Meanwhile, Rosen (1908), published “Figurative art in the childhood of peoples” in the German *Journal for applied psychology*; Van Gennep (1910), published “Children’s drawings and prehistoric drawing” in the French *Archives of psychology*, while Vierkandt (1912), issued “The drawing of native people” in the German *Journal for applied psychology*. In the field of education, Potpeschnigg (1912), published a significant article entitled “From the childhood of figurative art”. Interest in origins continued to increase with a book by Hoernes (1909), *Nature and primaeval history of people* and an article by Hoernes (1914), on “The origins of figurative art”. Rouma (1913), in a major book on *The graphic language of the child*, summarized the earlier findings of Passy, Clark, Kerschensteiner and others.

In Leipzig, Lamprecht began a collection of children’s drawings and sculptures. This collection was taken over by Kretschmar (1910), who articulated his version of the ontogeny-phylogeny analogy in an article on “Children’s art and primaeval art”. By 1913 the collection had over 300,000 pieces and became the subject of an exhibition described by Busse (1914), in an important article on “The exhibition concerning comparative developmental history among native people, children and in primaeval times”. He noted that (3-4):

> the development of bodily foreshortening, in which a full frontal view (Bushman, Palaeolithic, Eskimo) precedes a three quarter view, is shown in connection with spatial perspective....Also the problem of inverted perspective (Wulff) is illustrated using examples from Japanese and Bushman art. The development of landscape drawing is shown through bird’s eye perspective with a division of all
houses and trees in a plane to the development of the footline, later the ground-plane and finally the horizon emphasizing the difficulty of the middle-ground. Busse dismissed as wrong the theory of Levinstein according to which children’s drawings and culture in general involved a gradual rotation from a frontal towards a profile view, claiming instead that as soon as one had what were initially unfinished body parts (e.g. head and foot studies), they were also represented in their broadest dimension (8): “The terms frontal (Face) or profile drawing must therefore appear as misleading as a standard for the figurative representation of a form. Hence we reject both the frontal principle and the profile theory and replace these concepts with aesthetic regularities resulting from the material difficulty of the two expressive forms, which we describe as schemata of the tendency towards flatness (Flächenzwang) and the tendency towards a block (Blockzwang).” This article was published in the acts of the congress for aesthetics and general art history (Kunstwissenschaft) in which Busse (1914) also published “Comparative developmental psychology of primitive art among native people, children and in primaeval times”. All this provides a further context for the theories of Schäfer (1919) concerning Egyptian art considered earlier (p. 42*).

Krötzsch (1917), continued these themes in Rhythm and form in children’s freehand drawing as did Kühn (1923) in The art of primitives. Wulff (1927), in The art of the child, claimed that the development of their figurative and sculptural formation suggested that there were two main phases in the development of children’s drawings. Between the ages of 6 and 9 they learned to draw an elevation. At about the age of 10 they learned to integrate objects along a same ground line. Graeve (1932), published a dissertation, Investigation into the development of drawing in all is components in children from 3 to 14 years and comparison of these components among one another with special reference to phantasy drawing and particularly also courses of events (narrative pictures).

In this context, the developmental work of Piaget (see below) emerges in quite a different light. His work was a natural outgrowth of analogies and problems that had inspired two generations of scholars. Piaget largely ignored the cultural side of the ontogeny-phylology discussion and focussed his attention on the development of children’s spatial abilities. Where his predecessors had limited themselves to general claims, Piaget set out to do carefully controlled tests. This led him to redefine the whole question of stages.

Meanwhile, others were challenging these analogies between ontogeny and phylogeny. Bouman (1918) in an article on “The biogenetic law and the psychology of primitive figurative art” attacked parallels between the development of culture and the child in light of the amazing realism evidenced by early cave drawings. Franz Boas (1927), in his book on Primitive art cited Vierkandt’s (1912), distinction of three types of representation, namely suggestive (andeutend), descriptive (beschreibend) and perspective (anschaulich), claiming that (80): “The perspective type does not develop from the former two as the result of an evolution; it is based on a distinct mental attitude, the early presence of which is manifested by the realistic, perspective paintings of a number of primitive tribes.” Kellogg (1969), one of the greatest collectors of children’s art also minimized the significance of perspective (210): “Scholars who rate archaic art in terms of perspective rely too much on relatively recent developments in art and too little
on the Gestalt constructions of spontaneous work. They prefer to look for pictorial or symbolic meaning in art, rather than for structures which are appealing in themselves”.

Even so these ontogenetic-phylogenetic analogies whereby development of skills in children supposedly mirrored those of culture as a whole have lived on. They were the subject of a major study by Munro (1963), on *Evolution in the arts and other theories of culture*, which was reviewed negatively by Gombrich (1964). They have also continued to exercise a certain fascination in psychologists such as Gablik and Blatt (see above pp. 8-10*).

5. Anthropology

As was suggested in the previous section, in the nineteenth century anthropology remained integrally connected with ethnography and closely linked with both sociology and psychology. In the twentieth century, as de Folter has noted, cultural anthropology has been an important source for concepts of reciprocity that have become very important for concepts of perspective in sociology (see below). For instance, *Hobhouse* (1906) in *Morals in Evolution*, named reciprocity as “the vital principle of society.” *Malinowski* (1926) in *Crime and Custom in Savage Society*, referred to reciprocity as the basis of social structure. He distinguished between legal, economic, and ritual or ceremonial forms of reciprocity. This principle of give and take was pursued by *Mauss*, in his *Essay on the Gift. Form and Reason in Archaic Societies*. Similarly, *Thurwald*, in his *Economics in Primitive Communities*, claimed that exchange of goods was “the outcome of the principle of reciprocity which pervades every relation of everyday life and is exemplified in many other ways.”

Anthropologists have also explored effects of culture on perception of perspective. *Thouless* (1933), found that Indian students showed a greater tendency toward phenomenal regression to the real object (cf. p. 98) than English students, and concluded that a racial difference in perception accounted for the absence of perspective and shadows in Oriental art.

Since children at early ages inevitably have problems with perspective, anthropologists were led to assume that so called primitive tribes would be unable even to recognize perspectival images. The studies of *Hudson* (1960, 1962, 1967), seemed to confirm this assumption, as did the work of *Mundy-Castle* (1966), on Ghanaian children. *Kilbride* and *Robbins* (1968), claimed that pictorial depth perception in terms of linear perspective improved with education among the Baganda in Uganda. *Deregowski* (1968, 1984), supported these conclusions while noting difficulties. Meanwhile, a student of *Gibson*, *Kennedy* (1974), used a basic examination of line drawing as a point of departure to challenge these findings arguing that these abilities may be innate.

The work of *Haaland* (1976), in Nepal, has provided important evidence to show the effectiveness of perspective among illiterate tribes. Haaland used a series of objects ranging from the everyday to slightly less familiar. Persons were shown these objects in the form of six kinds of drawings (fig. 54, pl. 53-54) and were asked to arrange these in the order of comprehension: i.e. which were easiest to read and which were more difficult. It was found that photographs and perspective drawings were unequivocally the most comprehensible. John Hemming, President of the Royal Geographical Society,
informed me (personal communication), that South American Indians, many of whom have never seen a white man, have no trouble recognizing photographs. Moynihan and Mukherjee (1981), reviewed literature concerning visual communication with non-literate persons in Northern India.

1. ordinary photograph
2. block out (i.e. photograph without any background)
3. threetone drawing (i.e. in perspective)
4. line drawing
5. silhouette
6. stylised drawing

Fig. 54. Six kinds of drawing used by Haaland (1976).

With respect to discussions of method the work of Claude Lévi Strauss was very important. His *Structural anthropology* (French 1973, English 1976), had a first part entitled “Perspective views” in which he discussed the scope of anthropology. He noted that (11):” Social anthropology does not confine itself to a part of the domain of ethnology; it does not separate material culture and spiritual culture. In its own perspective - which we shall have to define, it is equally interested in both”. Later in the same study, he identified two main approaches (47): “The real opposition lies between two different manners of looking at history. One relies directly on documents, ‘written by the actors themselves in their languages’ or on monuments decorated with figures. The other which is practiced at this time between most of the theoreticians of ethnology is a form of ideological history which consists in putting observations in chronological order, in many manner found intellectually satisfactory”. Hence, for Lévi Strauss perspective was a way of looking or a point of view. Sometimes this was implicit as on the occasion when he used the phrase (65): “in the same perspective”. On other occasions this meaning was explicit as in his discussion of human societies in *Race and history* (342): “From other perspectives, they are situated at different ends from one another, so we would end up with different classifications, depending on the point of view elected”.

One very significant development of the 1980’s was the regular use of film and other media in both anthropology and sociology. This led to a new field termed visual sociology, initiated largely through the efforts of Leonard Henny (Utrecht), whose *International Journal of Visual Anthropology* (1984 ff.), records these developments and assesses the importance of visual information in the form of pictures, diagrams and sketches in both contemporary and historical terms.

6. Sociology

The evolutionary ideas of Charles Darwin were applied also to the realms of society and culture, and led to social darwinism. As part of his *System of synthetic philosophy*, Herbert Spencer wrote a three volume *Principles of sociology* (1876, 1893, 1896). While he focussed on social structures and relationships it is striking that his research programme called for the study of aesthetics (6):

which, as exhibited in art-products and in the correlative sentiments, have to be studied in their respective evolutions internally considered and in the relations of those evolutions to accompanying social phenomena. Diverging as they do from a
common root architecture, sculpture, painting, together with dancing, music and poetry, have to be severally treated in connection with the political and ecclesiastical stages, with the co-existing phases of moral sentiment and with the degrees of intellectual advance.

Spencer himself did not carry out this plan. Nor did Benjamin Kidd (1894), in his Social evolution. It is striking however that this was translated into German within a year (1895) and, like the work of Baldwin mentioned in connection with ethnography, attempted to relate art and society systematically. Meanwhile, Guyau (1889), in Art from the sociological point of view considered (56-73) “The expression of individual and social life in art,” problems of realism (74-118) and displacement in space (101-107).

The early development of sociology remained closely linked with the rise of ethnology, anthropology and art history. Hence Charles Letourneau (1892), considered the development of painting (114-122) in his Sociology along the lines of ethnography. Similarly Vierkandt (1908), in Continuity of social change. A sociological study, included a section on art (46-53), where he drew on the work of Holmes in the Reports of the Bureau of Ethnology (189*). In an earlier work, Nature-peoples and culture-peoples. A contribution to social psychology, Vierkandt (1895) touched on the question of perspective (238). Neither he nor his colleagues studied perspective in detail. Their contribution lay in pointing to its social context. This theme was also explored by Mannheim (1919, 1929 etc.), whose work has been considered earlier in the context of philosophy (above p. 170*).

Georg Simmel, one of the fathers of systematic sociology, in his On Social Differentiation (1890), developed the notion of viewpoints in his discussions of method. He noted, for instance, that sociology: "in its present state (it) only gives a new standpoint for the consideration of known facts. Therefore it is particularly desireable to fix this standpoint." He claimed that: "In the social sciences there is only a quantitative preponderance of the combinatorial elements relative to the other sciences, whence it appears particularly appropriate to bring the viewpoints through which these combinations occur, to a theoretical consciousness." Simmel was conscious that the concept of perspectivism was controversial and went against some traditional views. He acknowledged, for instance that: "At least it appears as if there is no consensus to be established between these two definitions of manners: one in the idea of an a priori approach culminating in an eternal value order; the other based on a the concept of a person oriented value perspectivism." He also noted that: "The principle of an ethical monadology, of a perspectivism of values is also actually hardened by those who only concede a modest place to it in their teaching." Simmel (1922), pursued these ideas in Sociology. Studies concerning the forms of socialization, which included a chapter on “Space and the spatial orders of society”.

Elsewhere, Simmel claimed that "the differentiation of the societal spirit into the sum of the reciprocal relations of its members lies in the direction of modern spiritual life," and he specifically defined society as "the sum of the reciprocal relations of its members," an idea that was directly acknowledged by Leopold von Wiese in his General Sociology as the Teaching of Relations and Relationships between Persons (1924). According to Von Wiese sociology was essentially about relations,
Howard Becker, the student of both Scheler and Leopold von Wiese in Cologne, pursued these themes in his translation which was also an adaptation entitled *Systematic Sociology* (1932). He too developed the idea of sociology as relation. At the same time he emphasized the importance of viewpoint. In chapter one, section five, for instance he specifically discussed "the distinctive character of sociological viewpoint." On one occasion he spoke of the "the complementary function of two different viewpoints." In describing his approach to sociology he used optical metaphors: "when the sociologist properly focusses the lens adapted to his specific purposes; nothing other than processes of association and dissociation appear in the field of view," or again: "daily life viewed through the sociological lens offers a picture of ceaseless approach and avoidance by selecting a narrow field of focus...." He also used the optical metaphor of a searchlight: "Sociology illuminates with the searchlight of its method a portion of the clearly visible surface of the social globe; at the edges everything becomes dim." Elsewhere he specifically used perspective metaphors as in a section headed: "Uniformation from a historical perspective," or on another occasion when he admitted that: "Difficult but scientifically necessary is the task of bringing order and perspective into the swirl of multifarious relations and plurality of patterns filling the course of interhuman life as it passes in space and time.

Ultimately Becker was careful to note that "For the specialist sociologist, sociology is not merely viewpoint, modes of observation, attention turned toward groups, but literally the science of of humans living-together, nothing more or less." He maintained this view in a much later book on *Man in Reciprocity* (1956), where he claimed that: "for us sociology represents the scientific study of man in reciprocity, or less broadly phrased, the predictively oriented study of interpersonal or intergroup relations as such," an idea which he summed up in his pithy phrase: "Man becomes human in reciprocity."

As de Folter has noted, Theodor Litt belongs to this tradition of formal sociology through his attempts at creating a phenomenology of spiritual (geistigen) reality. Litt (1926), in *Individual and Society. The Foundation of a Philosophy of Culture*, criticized the concepts of relation (Beziehung) and reciprocal effects (Wechselwirkung) because they were expressed as an external occurrence between objects or persons rather than being thought of as the totality of reality and because they were bound in an atomistic approach to social science whereby the social whole was reduced to an aggregate of externally related elements.

In Litt's view a "reciprocity of perspectives" was "the original phenomenon of society." This, he claimed occurred on two levels. A first level was with respect to the narrow connection of moments of experience of an individual. He spoke, therefore, of a perspectivism of experiences, which included not just the ranging of spatial perspectives of one beside another but also temporal perspectives of one after another. These spatial and temporal perspectives were interlocked and in this interlocking he criticized the
simple after and beside one another of isolated elements of objectivizing thinking. A second level was a reciprocity of perspectives with respect to different subjects. Here it was not a question of an equation whereby I know that the you is filled with a life content, which is perspectivally organized as mine is. The relation is much more immediate:

They are not identical or comparable but rather perspectives that belong together, that influence one another reciprocally and are bound up with one another, that live in you and me and my, your immediate knowledge about them is simultaneously a knowledge about how these are interwoven with you.

De Folter has noted several other sources for these concepts of reciprocity: a) exchange theories in cultural anthropology (see above p. 203*), b) the exchange theory of Homan and Blau and c) the symbolic interactionism of Mead (1926) who, in a significant article on "The objective reality of perspectives", claimed that the limits of social organization were to be found in the ability or inability "to take over the perspectives of the other, to put oneself in their place" and noted that taking the role of the other "always implies a reciprocity of perspectives." Mead (1969) claimed that "The object of perception stands as a physical object relative to the organism. This situation is termed perspective. The relation between field of perception and organism in perspective is social." Mead also held that a social individual "always finds themself in a perspective which belongs to the community within which one's concept of the self has originated."

De Folter (1983) explored in some detail how Husserl's reciprocity of perspectives (considered above p. 187*), related to the ideas of Alfred Schutz, the Viennese banker, who became one of the key figures of American sociology. He noted that both dealt with reciprocity of perspectives in ideal terms. Although Husserl ultimately sought to solve the problem of the social world in the transcendental sphere and Schutz attempted to do in the mundane sphere, both remained idealizing: that of Husserl an idealistic and that of Schutz a pragmatic idealizing. The thesis of reciprocity was, moreover, linked with concepts of the "normal", "optimum" (Optimalität) and "truth". De Folter noted that this thesis of reciprocity remained oriented around an ego-logical perspective and underlay a basic tension between the personal sphere of the ego and the sphere of the alter ego. He concluded with a proposal as to how this could be overcome:

At the level of concrete, factual concertation processes one can overcome the determination of reciprocity as an ideal and ego-logically established normality. It is a question of no longer fixing the normality of the reciprocity of perspectives as an ego-logically constructed Ideality, but rather as based on a factual, process that is originally based on us [rather than me].

Schutz (1973-1975), in his classic *Problem of social reality*, was very explicit about the role of perspective, and perspective views as an integral part of daily life (II,22):

Other men whom I experience do not appear to me in identical perspectives. They present themselves to me under different aspects and my relations with them have different degrees of intimacy and anonymity. The modifications which determine
my relations to others and my experiences of them are a central factor in the constitution of the several domains within the social world.

Schutz outlined the transition from direct to indirect experience of social reality (II,37):

The gradations of experiential directness outside the face to face situation are characterized by a decrease in the wealth of symptoms by which I apprehend the Other and by the fact that the perspectives in which I experience the Other are progressively narrower. We may illustrate this point by considering the stages by which a fellow-man confronting me becomes a mere contemporary. Now we are face-to-face, saying good-bye, shaking hands; now he is walking away. Now he calls back to me; now I can still see him waving to me; now he has disappeared around a corner. It is impossible to say at which precise moment the face-to-face situation ended and my partner became a mere contemporary of whom I have knowledge (he has, probably, arrived at home) but no direct experience. The gradations of directness can be also illustrated by a series ranging from conversation face-to-face, to a conversation by phone, to an exchange of letters, to a message transmitted by a third party. Both examples show a progressive decrease in the wealth of symptoms by which I experience my partner and a progressive narrowing of the perspectives in which my partner appears to me. While we may legitimately distinguish between direct and indirect experiences of social reality, we must realize that these are polar concepts between which exist many concrete transitional forms.

In other words perspective was an important tool in identifying different points on the spectrum between direct and indirect social reality. Or rather this was one of its functions. Schutz also discussed how perspective played a central role in our own social world (II, 72):

Our practical interest alone, as it arises in a certain situation of our life, and as it will be modified by the change in the situation which is just on the point of occurring, is the only relevant principle in the building up of the perspective structure in which our social world appears to us in daily life. For, just as all our visual apperceptions are in conformity with the principles of perspective and convey the impressions of depths and distance, so all our apperceptions of the social world necessarily have the basic character of perspective views.

Hence, he claimed, (II,81) “each of us considers himself as the centre of this world.” By contrast, “Everyone, to become a social scientist, must make up his mind to put somebody else instead of himself as the centre of this world, namely, the observed person”. Schulz noted a tendency to treat these observed persons as “puppets”, or “ideal types” as Weber termed them, but then added that social scientists could not themselves become idealized abstractions (II,83):

What counts is the point of view from which the scientist envisages the social world. This point of view defines the general perspective framework in which the chosen sector of the social world presents itself to the scientific observer as well as to the fictitious consciousness of the puppet type. This central point of view of the scientist is called his “scientific problem under examination”.

In a scientific system the problem has exactly the same significance for the scientific activity as the practical interests have for activities in everyday work. The scientific problem as formulated has a two-fold function:

a) It determines the limits within which possible propositions become relevant to the inquiry. It thus creates the realm of the scientific subject matter within which all concepts must be compatible.

b) The simple fact that a problem is raised creates a scheme of reference for the construction of all ideal types which may be utilized as relevant.

Hence perspective also provided a key for what Schutz termed the principle of relevance. He returned to perspective in discussing how time and experience change our perceptions (II,115): “What belongs to the past can never be reinstated in another present exactly as it was. When it emerged, it carried along empty anticipations, horizons of future developments, references to chances and possibilities; now in hindsight, these anticipations prove to have been or not to have been fulfilled; the perspectives have changed....”

Skidmore (1975) in his *Theoretical Thinking in Sociology* offered a more general definition of perspectives as: "collections of concepts which are important basically as sensitizing agents. They point out important aspects of reality. But perspectives are relatively less coherent and developed internally." Hölscher (1978 etc.), explored connections between formal and social space in the development of public awareness (Öffentlichkeit) in early modern times, arguing that the methods of perspective were a necessary basis for the iconographical representation of social and institutional processes insofar that it introduced the possibility of constructing homogeneous spaces for interaction in which an action was spatially and temporally precisely fixed. Becchi and Riva (1980), explored relationships between physical space and perceived accounts of that space by those living in it, using as their subject the town of Viggju in Northern Italy.

Faigley (1985), rejected both positivism and the window pane theory of knowledge. He argued that reality is unknowable apart from language and went on to claim (1986, 535) that writing “can be understood only from the perspective of a society rather than a single individual”. This Faigley termed the social perspective. Thralls and Blyler (1993), in *Professional communication*. The social perspective, offered an important review of recent developments, identifying three emerging theoretical approaches: the social constructionist, the ideologic and the paralogic hermeneutic.

Building on the ideas of Rorty (1979, 170), that knowledge is the “social justification of belief” and Geertz (1983), who claimed that all knowledge was local, Bruffee (1986, 774), claimed that “social construction understands reality, knowledge, thought, facts, texts, selves, and so on as community-generated and community-maintained linguistic entities” and hence argued (775) that knowledge was social by nature rather than “individual, internal and mental”. In this approach, the vague notion of community moved to a central position, as did the notion that knowledge was merely a question of consensus. Hence the ways and means by which such beliefs were integrated into a community’s “knowledge store” became more important than the question of truth.

So called discourse conventions of professional societies such as engineers were studied as indices of community membership. Bruffee (1984, 641), claimed moreover that
“thought is internalized public and social talk...and writing of all kinds is internalized social talk made public and social again”. As a result collaboration in the form of peer critiquing, peer tutoring, reader-response groups and group-writing projects emerged as fundamental approaches in learning and education. (Ironically these claims come increasingly from persons who have no writing skills themselves and espouse these new methods while blithely forgetting that a generation ago when individuals were not yet out of date no-one would have dared even think of themselves as educated unless they had a certain proficiency in writing).

A second, ideologic approach has been concerned with rhetoric as ideology and has focussed attention on the ways in which communities establish conventions, which “socially construct relations of domination”. Interestingly enough the champions of this approach have been particularly interested in the use of new electronic technologies as ways of undermining authority. As Thralls and Blyler (1993,22), citing Kiesler, Siegel and McGuire (1988), noted: “networking fosters democratization because the anonymity of networking interchanges eliminates many cues of status and authority”.

A third, paralogic hermeneutic approach, emphasized the uncodifiable nature of interpretation, arguing that one should focus on “the rapport experienced by communicants as they interact”, their point being that we have certain commonsense notions that exist independent of conceptual or constructionist schemes. This approach has given new meanings to the terms internalists and externalists. Internalists, they claim, assume a Cartesian split between the human mind and that which exists outside it, whereas externalists deny this split, arguing that understanding comes from “the give and take of communicative interaction”.

Thralls and Blyler (1993,22), raise the important question whether the ideologic and paralogic hermeneutic approaches can be incorporated within current professional communication courses without undermining them and conclude (32) no “if the ideologic approach is understood to mean critiquing and maybe even resisting the larger economic values of a commodity culture”. Interestingly enough Miller (1989) has noted that “industry-university collaboration” threatens to reproduce private corporate interests and to reduce students to being tools of capitalist ideology.

Anson and Forsberg (1990, 202), speak of “strategies for social and intellectual adaptation”. Harris (1989), emphasizes the importance of like-mindedness. Kent (1991, 433) speaks of communicants needing to make “fewer guesses” about each others’ interpretations. Such statements suggest a growing herd mentality, a trend towards homogenization and sterilization as if persons could be purified like milk, and a growing hubris that we can “know” the other without much effort. What was traditionally a lifetime’s exploration of another individual is now reduced to a game of ever fewer guesses. Amid a rhetoric of democratization of the workplace that hides structures of authority, these approaches diffuse tensions away from an increasingly invisible boss while leaving no doubt that one has to please the employer. Traditional allegiance to an individual who also served as an authority figure in the positive sense of providing an example, are supposedly being replaced by allegiance to an impersonal firm which can then fire 500, 1000 or even greater numbers of authorities in the interests of “streamlining” or simply because profits have gone down.
The dangers of this so-called social perspective go far deeper than this. It is important to recognize, for example, that these approaches destroy any sense of privacy and effectively eliminate traditional concepts of the individual. In the past, the individual as conceived in the West developed an inner world and one developed various skills including speech, writing, painting and other arts in order to communicate the beauties of these inner mindscapes. Now the claim is that there is no such thing as an inner world. Hence the knowledge that traditionally served as ingredients for this inner world can also be dismissed and the one can pretend that the forms of communication can replace content. This is a new twist to McLuhan’s concept of “the media is the message”. Or perhaps we are witnessing the real consequences of a completely media dominated society: that there is no longer even an awareness of content. Everything is form.

Everything is a consensus that aims to be “politically correct” but succeeds only in being so bland that it lacks any real character.

The historian of ideas will recognize that these so called new approaches of social perspective are actually a twentieth century revival of strands of nineteenth century thought. One strand, perhaps most eloquently characterized by Kierkegaard emphasized the central importance of individuality, that we paradoxically cannot know another individual until we have plunged into the depths of our (potential) isolation and only then reach out. Another view, most brilliantly characterized by Marx, argued that the individual per se did not count, that power and reality ultimately lay only in groups and masses. Similarly consciousness within the individual did not count, nay did not really exist. For consciousness too was a group phenomenon which increased as the masses increased in size. Thus quantity of groups was weighed against quality of individuals all of which heralded in an uncanny way twentieth century concerns with students as basic income units (B.I.U’s) or merely as “warm bodies”.

These latest developments might seem a natural evolution from the approach of Schutz which as we have noted, drew on older philosophical traditions. In fact this so-called social perspective of the 1980’s and 1990’s has very little to do with perspective in its older senses and these two approaches can be seen as central to some of the fundamental struggles of our times. Integrally connected with the traditional concept of the individual is an emphasis on quality, independence, privacy and the development of a particular viewpoint. This is being opposed by a focus on groups that brings with it an emphasis on quantity, interdependence or often simply dependence, no sense of privacy and a concern with consensus. The individual emphasizes inner worlds, levels of meaning and the importance of spiritual gain all of which assume an interior dimension. By contrast the group tends to exteriorize everything, emphasizing exterior worlds, levels of discourse as if externalized speech were all, and ultimately material gain. The individual is traditionally a-political: the group is highly politicized. The individual has a firm sense of knowledge as facts and learning as a quest for truth. The group looks for knowledge in construction, interaction and claims that learning is a quest for agreement. The individual emphasizes content: the group prefers form. The individual strives to be rather than to seem (esse quam videri): the group strives to seem rather than to be (fig. 55).

<table>
<thead>
<tr>
<th>Traditional Perspective</th>
<th>Social Perspective</th>
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<tbody>
<tr>
<td>individual</td>
<td>group</td>
</tr>
<tr>
<td>quality</td>
<td>quantity</td>
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</tbody>
</table>
independent  (inter-) dependent
privacy       no sense of privacy
particular viewpoint  consensus
inner worlds  exterior worlds
levels of meaning  levels of discourse
spiritual gain  material gain
a-political  politiz ized
content  form
knowledge as facts  knowledge as construction, interaction
truth  agreement, political correctness
be (substance)  seem (illusion)

Fig. 55. Basic differences between traditional perspective and so-called social perspective in its new form.

It is striking to what extent these two positions affect everything from the person to society’s concept of knowledge and even truth. It is equally striking how the group position entails a narrowing of choice. In the past the individual was seen as having both interior and exterior interests with a freedom to choose between a contemplative or an active life. In a group where everything is externalized this choice disappears: there is no longer room for the interior and only an external, active life remains.

The greater this tendency to externalize our personal worlds, the more it will manifest itself in our public codes and institutions. We have already noted Miller’s warnings concerning industry-university collaboration. However it is likely that the problem runs even deeper than Miller suggested. Businesses do more than convey notions of commodities to universities. They lead us to think of ourselves and our students as commodities, as if there were nothing else but a barter system even in the realm of the human spirit. The trend to assess success of scholars by the size of their grants; the mania to quantify even when doing so is clearly at the expense of quality are dimensions of these problems. In the past, distant wars were often a favoured method of diverting attention from domestic problems. Are the new trends towards distance education merely a variant on this theme, or do they truly reflect new dimensions of technology?

7. Psychology

Some context for the history of psychology has already been provided (see above p. 87 ff.*) in the discussion concerning relations between vision and representation where differences between the Leipzig and Berlin schools were outlined and the work of Gibson was examined. No attempt will be made here to retrace the entire history of the subject. For this the reader is referred to standard works such as Boring’s History of experimental psychology (1942). Our concern is to identify some of the chief themes that have linked perspective with psychology in the twentieth century. Most of these have been linked with either the perceptual or conceptual schools. Meanwhile there have been emerging fields such as perspective taking and social perspective. Each of these will be considered in turn.
Perceptual Psychology

As noted earlier (fig. 8) that which some now refer to as a perceptual school includes what were traditionally the two main opposing schools namely those of Berlin and Leipzig. The Berlin school in its American version as the Gestalt school considered some general problems but emphasized perception of form, whereas the Leipzig school in the American version led by Gibson focussed on perception of information.


Perception of Form

The Berlin school, which became known as the Gestalt School, focussed attention on the importance of the constancies through the classic studies of Koffka (1935), Köhler (1947), and Wertheimer (1912, 1925). Arnheim (1956), developed these themes in *Art and visual perception* where he considered ten basic topics: balance, shape, form, growth, space, light, colour, movement, tension and expression. In his section on space, Arnheim devoted eight pages (279-286) specifically to the problem of perspective. For him it represented the co-incidence of two completely different principles. On the one hand it was the culmination of an effort to re-integrate pictorial space. As such it was a conventional method for organizing shapes available in the medium. On the other hand “it is what we get when we set up between our eyes and the physical world a vertical plate of glass, on which to trace the exact contours of the objects as we see them through the glass” and in this sense “perspective is a mechanical copy of reality”.

According to Arnheim, violations of perspective were committed “by the masters from the moment the rule had been set”. Even so, he insisted the principles of mechanical imitation and geometric construction introduced by perspective posed a tremendous burden (281): “The artist had to fight them in himself as well as in his patrons and critics. They contributed to an all time low of popular visual culture in the nineteenth century, and even in the modern movement provoked a violence of dissension that diverted much creative energy to the cult of extravagance”. Arnheim did concede that (283) “central perspective makes for a richer compositional pattern” and identified three factors determining the strength of visual experience obtained by perspective: the angle of convergence, extent to which the distorted object is visible and distance of the observer from the picture. For the most part, however, he was intent on arguing that “correct” perspective was not the artist’s concern: correct amount of convergence depended “entirely upon the expression and meaning to be conveyed”. Hochberg (1957), reviewed the development of these schools in his important article on “Nativism and empiricism”.

Perception of Information

The so called Leipzig school as developed in America by Gibson emphasized information rather than form and focussed specifically on texture, surface, gradients and grids. In this context, there has been a much greater emphasis on perspective. Paradoxically, this approach to information has focussed discussion on line drawings which reduce the complexity of perception to minimal situations. These schools in perceptual psychology have focussed attention on a series of problems: monocular and binocular depth perception, illusions, motion perspective, the nature of drawing and the
limits of rules of both perception and representation, as well as effects of culture on perception which have been considered earlier.

**Monocular Depth Perception**

Clarapède (1904), had drawn attention to the paradox of monocular stereoscopy. Hillebrand (1910), also important for his studies on subjective perception of parallels, studied problems of monocular localisation, which led him into polemical debates against Witasek. Zoth (1908-1916), noted that when paintings were viewed through a monocular tube (*Plastoskop*), this increased their brightness, clarity and their three-dimensionality. These phenomena were explored by Strieff (1923), and led Ames (1925), to list ways of increasing the illusion of depth from a single picture, namely: looking at a picture with one eye only, looking at a picture through an iconoscope; viewing a picture from a greater distance; changing the convergence of the eyes from that normally required by the distance from which the picture is viewed; looking at the picture through a small hole 2 mm. or more in diameter held close to the eye; changing the accommodation of the eyes from that normally required by the distance from which the picture is viewed; looking at a picture binocularly with one eye receiving a sharp image and the other a blurred one; looking at the reflection of a picture in a mirror; looking at a picture with abnormal rotation of the visual images about the axes of vision. This led to a list of four objective depth factors: scale or perspective; known forms or relationships; shadows; aerial perspective; and five subjective depth factors: character of the monocular image; corresponding images on both retinas; rotation of the visual fields about the axis of vision; convergence and accommodation. Miles (1930), explored ocular dominance in human adults. Schlosberg (1941), examined stereoscopic depth from single pictures summarizing the earlier research of von Karpinska (1910), Ponzo (1911), Zoth (1915), and Ames (1925), before examining a number of means of creating stereoscopic depth from single pictures (fig. 56).

1. Looking at a picture from a distance
2. Monocular viewing
   - Looking through a tube
   - Looking through a lens
   - Looking at a picture monocularly in a mirror
3. Partial binocular vision
   - Blurring the image in one eye during binocular vision
   - Prisms to displace or rotate the image in one eye
4. Full binocular vision
5. Iconoscope

Fig. 56. Different means to create stereoscopic depth from single pictures according to Schlosberg (1941).

Holway and Boring (1941), in their exploration of determinants of apparent visual size, considered size constancy, binocular observation, monocular observation, artificial pupil, reduction tunnel. They claimed that (37): "Binocular regard gave a function close to the function for size constancy". Boring (1946), in a more general article on "The perception of objects", argued that perception is more than sensory perception, that (99): "because
objects are permanent, a perception of an object tends to remain constant”. He concluded that this was caused by both heredity and through learning.”

**Binocular Vision and Depth Perception**

In the 1490’s, Leonardo da Vinci became extremely interested in problems of binocular vision particularly in terms of consequences for representation and these concerns have been used to explain why he gave up painting for several years (c.1498-1503). Veltman (1986), studied these passages with respect to Leonardo’s perspectival studies. Inspired by Leonardo, Wheatstone (1838), developed the stereoscope (see p. 135). Dove (1841), first examined the effects on stereoscopy of momentary illumination. Fechner (1859), the father of psychophysics, published an important essay “On some relations of binocular vision” in which he examined contrast, double images and after effects of colours seen by both eyes.

Streiff (1903), in a dissertation studied the perception of a white square by the right and left eyes as they are moved to the side. Von Karpinska (1910), in a significant article on “Experimental contributions to the analysis of depth perception” reviewed the literature since the time of Dove and set out to explore more precisely aspects of the subjective field of vision, with specific reference to ways in which momentary lighting of stereoscopic images could produce effects of depth perception.

Streiff (1923), studied further effects of flattening in binocular vision. Isakowitz (1923), criticized his explanation to which Streiff (1923), replied. Vetri (1911), raised other questions concerning the properties of perspective with respect to binocular vision. Eaton (1919), took up these problems anew in “The visual perception of solid form” where he claimed that perspective played a more important role than binocular vision. Mayer-Hillebrand (1947), an experimental psychologist, claimed that linear perspective was based purely on monocular conditions and that because it ignored entirely the realities of binocular vision, it deserved to be abandoned.

This topic was taken up anew by Böck (1953,1954). Zajac (1959), summarizing an unpublished doctoral dissertation (Edinburgh, 1951), examined conditions for depth perception of stereoscopic images and concluded that they depended on three main laws: of the visual angle, intersection of visual lines, and of relief. Julesz and Spivack (1967), generated random line stereograms in which the only monocular cues were minute breaks occurring in thin vertical or horizontal line grids and found that the resulting stereograms yielded global stereopsis. Ross (1976), examined perception of stereograms changing at random and concluded that (8) “what we see is an interpretation of the external world, ordered within a framework the visual system imposes because of the attitude it adopts”.

**Illusions**

Already in Antiquity, optical illusions were the chief theme of Euclid’s *Optics*, and in a sense the whole history of optics can be seen as an attempt to discover criteria whereby the eye will not be deluded by such deceptions. Renaissance authors such as Piero della Francesca and Leonardo da Vinci assumed that the unaided eye would inevitably be deceived and believed that their treatises on perspective offered a way of getting beyond, or rather correcting, these potential deceptions.
Optical illusions acquired a new role when, in the first half of the nineteenth century, the studies of Volkmann (1839), Hering (1861), and others seemed to have demonstrated definitively that there could be no simple one to one correspondence between the retinal image and that which a person sees. It was believed that if one could identify the parameters under which the eye is deceived by geometrical illusions, one could learn about how the visual process functions. A first series of these illusions were discovered shortly after the mid-nineteenth century: notably Zöllner (1860), Poggendorff (1860), and Hering (1861). A second important wave of illusions emerged in the last decades of the nineteenth and opening decades of the twentieth century: e.g. Delboeuf (1892), Müller-Lyer (1889, 1898); Wundt (1889,1898), and Ponzo (1912,1928). It will be noted that this second wave coincided with renewed debates concerning the nature of retinal images (cf. above pp. 89-90*).

Wallin (1905), published, at the author’s expense, his classic Optical illusions of reversible perspective: a volume of historical and experimental researches. He noted that these phenomena had been called conversion of relief (Wheatstone, 1838, Hardie); inversion of relief (Brewster, Sinsteden, Mohr, Mach, Loeb, Schröder), breaking (Umbrchen, Mach, 1866); twisting (Umstulpung, Mach, 1903, Dove); turned around (Verkehrte, Schröder) or inverted illusions (Umgekehrte Illusionen, Wundt); illusions of equivocal or ambiguous perspective (James, Sanford), reversals (Umkehrungen, Dove, Weber, Hoppe) and reversions of perspective (Le Conte, Stevens, Titchener). Wallin offered an excellent historical survey of the problem and provided a series of detailed experiments. The final section of his book reviewed the major theories in terms of two major currents: one, ideal, intellectualistic, psychical or psychological; the other ‘realistic’, sensationalistic or physiological. These he classed in terms of five subcategories (fig. 52*).

Ironically the first world war gave a new impulse to these studies given the practical consequences of illusions in the realm of camouflage. In his classic study, Luckiesh (1922), made one of the first serious attempts to list and to classify various optical and geometrical illusions. Werner (1924), pursued this theme.

Wallin claimed that there was direct, if not conclusive evidence, for the psychophysical theory of illusions which started from their empirical correlation with movement motives of the eye muscles which Wundt had described as follows (305): “whenever the point of regard necessitates an exaggerated expenditure of muscular energy in order to survey a given space, whether a line, area volume, angle or arc, that space is overestimated in relation to a compared space”. Wallin claimed that this applied to all classes of illusions of which he identified eight (fig. 57).

I. Psychological Theories
   A. The imagination theory proper
      The perspective theory (Hering, Filehne, Guye, Bezold, Thiery, 1896)
   B. The aesthetical-optical and mechanical-geometrical theory
      The confluence theory
   C. The association theory
   D. Psychophysical or Sensation Theory
Fig. 52. Wallin’s (1905) classes of the chief theories.

1. a. Variable illusions of extent
   b. Constant illusions of extent
   c. Variable illusions of direction
2. Fixation
3. Irradiation
4. Lens asymmetries, astigmatism and indirect vision whereby part of the image not clearly seen is changed by dispersion
5. Distance, size, position and nature of drawing
6. Manner of viewing the picture
7. Sensations which precede the act of apprehension
8. Effect of practice.

Fig. 57. Wallin’s eight classes of illusions.

1. Universality of the illusion content
2. Illusory perception is equal to the normal in immediacy, spontaneity and clearness
3. Illusion content may exist without being known to be illusory
4. Perspective can be controlled by purely physical means
5. In the geometrical outlines it has been possible to trace a definite axis of reversion
6. Reversions differ for different figures in respect to the following particulars:
   a) distortions
   b) difference between the two perspectives
   c) ease of reversion
   d) emergence of the perspective
   e) planosphere stage
   f) fixation
   g) monocular and binocular vision
7. Illusions are capable of quantitative treatment and results can be varied by varying the conditions:
   a) results differ numerically for one and two eyes
   b) different distances
   c) secondary positions of regard
   d) colour of the ground
   e) fixation
   f) reversions are possible in the indirect or peripheral retinal field
   g) inversion
   h) imagination or will
8. Influence of obliques in drawings
9. Illumination devices of various kinds
10. Covering a portion of the figure
11. Motion of the form, fixation, object, body, eyes, etc. with appliances for the free eyes
12. New remarkable, unpredictable perception contents from reversion
13. The physiological theory has accounted for all the above facts by appeal to definite factors applicable to each individual case, while the judgement theory has either offered no explanations or merely general references to mental powers.

Fig. 58. List of thirteen reasons cited by Wallin (1905) in favour of the physiological theory of illusions.

<table>
<thead>
<tr>
<th>Starlight</th>
<th>Telescope</th>
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<tr>
<td>Method of Observation Visual</td>
<td>Direct Photography</td>
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<tr>
<td>Instrument</td>
<td>Eye</td>
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<tr>
<td>Detector</td>
<td>Retina</td>
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<td>Intensifier</td>
<td>Nerve Signal</td>
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<tr>
<td>Output</td>
<td>Mental Processes</td>
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<tr>
<td>Electronograph</td>
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<tr>
<td>Data Handling</td>
<td>Description</td>
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<tr>
<td>Computer</td>
<td>or Drawing</td>
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Fig. 59. Methods of observation and output according to Weale.

The second half of the twentieth century saw new attempts to explain and classify various illusions. Robinson (1972), continuing the approach of Luckiesh, offered a more complete catalogue of all optical and geometrical illusions. Meanwhile experts developed essentially three different explanations in terms of perspective, size, and orientation.

Weale (1968, 99), suggested two major reasons for illusions: “the underlying information is either inadequate or fraudulent”. As an example of the first he cited the case of photographs of convex masks that appear concave. As a case of fraudulent information he cited Schröder’s staircase which he described as an isometric fraud noting that the illusion disappeared when regular perspectival cues were added. Weale also considered illusions which (102): “involve either an ambiguity or, more frequently, an apparent error by virtue of a three-dimensional situation not being recognized as such but interpreted as being truly two-dimensional”.

As an example, Weale cited two convergent lines encompassing equally long parallel straight lines. These seemed to increase in size towards the apex, an effect that disappeared when one added perpendiculars. Weale showed that the Poggendorf illusion of a seemingly discontinuous slanting line disappeared when the intersecting parallels...
were filled in or when the slanting line was tilted into a horizontal position. He demonstrated how this could also account for Hering’s illusion.

Weale was careful to note that not all illusions could be explained on these grounds. For instance, in the case of the so-called phump-doodle image, the illusion depends largely on the scale of the image and if one is able to minimise demands on eye-movements and memory by making it smaller, the illusion disappears. He also examined three-dimensional effects, movement of the object and of the observer. Weale (1975), examined illusions of apparent size as a function of contrast at a constant mean luminance. Weale (1978), noted that the Zöllner, Luckeish, Orbison, and related optical illusions disappeared when the distorting, but not the distorted, lines were defocused, concluding that these illusions “involve hypothetical orientational mechanisms in the human visual system”. Weale (1979), cited evidence to show that Leonardo and Mantegna were the discoverers of Mach bands. Weale (1982), returned to these problems to claim that some of the illusionistic phenomena associated with stereo- and colour stimulation are part of the visual “system” and hence could not be explained simply as perceptual concepts as psychologists had tried. Weale also produced a useful chart illustrating different methods of observation and output (fig. 55).

Quietly ignoring these insights, psychologists such as Gregory (1966,1970), argued that the Müller-Lyer and Ponzo illusions were related to perspectival situations which, once recognized, helped one to resolve these illusions. Kennedy (1974), using as a starting point Gibson’s insistence on the need to see things in their environment from different points of view rather than from a single station point, demonstrated that some of the most famous illusions, i.e. those of Hering, Müller-Lyer, Poggendorff, Wundt and Zöllner, disappear when seen from the side and from a series of viewpoints. According to this explanation one did not need to make appeals to perspective as does Gregory. Illusion were primarily a function of orientation.

<table>
<thead>
<tr>
<th>Spectrography</th>
<th>Spectrograph</th>
<th>Image Intensifier</th>
<th>Photomultiplier</th>
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<tbody>
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<td>Solid State Device</td>
<td>TV Camera</td>
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<td>Photograph or Electronograph</td>
<td>Electric Signals</td>
<td>TV Signals</td>
<td>Electric Signals</td>
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<td>Online Computer</td>
<td>Online Computer</td>
<td>Chart Recorder</td>
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<td>Online Computer Print Out</td>
<td>Paper tape or</td>
<td>Magnetic Tape</td>
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<td>Paper Chart</td>
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<td>Magnetic Tape</td>
<td>Magnetic Tape and Visual Display</td>
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**Illusions and Motion Perspective**

In anecdotal terms discussions of perception of motion perspective go back to ancient authors such as Lucretius who discussed the appearances of sails in moving ships. Ptolemy and Alhazen pursued these questions more fully in their optical treatises. Leonardo discussed several examples of motion perspective.

In the twentieth century, J. J. Gibson’s experience as an aircraft pilot during the second world war led him to stress the importance of gradients (1946), and transformations in the optic array (1957). Gibson focussed on correct perception and believed that a good theory
must explain incorrect perception by supplementary assumptions. Gibson and Gibson (1957), suggested that false shape constancy might account for illusions of motion. Others who focussed on motion illusions tried to identify the source of misperception in terms of specific factors: Ames (1951), proposed the role of past experience; Pastore (1952), considered gestalt factors; Graham (1963), suggested linear perspective.

Braunstein’s (1976), *Depth perception through motion*, made a valuable review of work in the field beginning with a consideration of three traditional cues to depth perception: accommodation, convergence, binocular disparity as well as secondary or pictorial cues, including interposition, relative size of familiar objects; relative size of similar objects, linear perspective and relative height. An assumption underlying this approach was that perception of flatness was primary and that perception of depth was something that had to be learned. Braunstein cited evidence against this assumption. With respect to illusions of motion in depth, Braunstein identified two basic classes: one involving illusions of misperceived direction of rotary motion with windmills, fans and rotating trapezoids; the other, where motion in depth was perceived in the absence of physical motion in depth as in the case of Lissajou figures and stereokinetic patterns. The information available in the optic array was explored, noting the importance of the projection plane, perspective gradients in the form of texture gradients, linear perspective and parallel projection as well as information available in rigid transformations of the x, y and z axes. Braunstein examined which of these transformations in two-dimensional projections led to the perception of depth, explored the significance of slant perception and reviewed two lines of research in the perceived direction of rotary motion: one, involving shadows and computer simulations of rotating objects; the other involving direct observation of rotating objects.

These two lines of research had led to two general conclusions: that accuracy in judging direction of rotation decreased with increased viewing distance and that accuracy was greater for some forms such as rectangles than for other forms (e.g. trapezoids). Braunstein outlined a model for the perception of rotary motion based on information processing which posited that (142) changes that are based on vertical perspective appear dominant; changes based on horizontal perspective have a secondary effect on direction judgments.

Underlying many of these studies of illusions and perception of motion have been assumptions that retinal images share projective invariants, which account for shape constancy. The origins of this projective thesis have been traced by Niall (1990), to Helmholtz and through the writings of Gibson (1950, 1966). Gibson (1979), explored effects of motion perspective further in his *Ecological approach to visual perception* but implicitly left open the question of precisely how the eye acquires information for motion in the visual array, suggesting however that awareness of invariants should help to explain shape constancy. These problems were further examined by Rock (1975,1983), Ulmann (1979) and Johansson (1950, 1974, 1980). Cutting (1986), believed that the angle of ratio also known as the cross ratio offered a solution.
Figs. 60-61. Motion perspective of objects on earth for a person moving straight down a country road and fixating at the horizon and motion perspective of objects on earth for a person moving from right to left along a country road and fixating at the horizon from Ralph Norman Haber, Maurice Hershenson, *The psychology of visual perception*, London: Holt, Rinehart and Winston, 1973, pp. 321-322.
Figs. 62-63. Motion perspective of objects on earth for an airbourne person from the focus of expansion on the horizon and for an airbourne person in a landing glide from J. J. Gibson, *The ecological approach to visual perception*, Boston: Houghton and Mifflin, 1979, p. 124.

Perkins (1972, 1982), experimented with projective drawings of cubes to study this problem. Shephard, Attneave and Frost (1969), used box shaped objects to assess sensitivity to principles of projective geometry. Niall and Macnamara (1989), challenged these views. Niall and Macnamara (1990), went further to claim that observers exhibited little sensitivity to projective properties independent of Euclidean properties” and hence that the cross-ratio did not play the role that some had assumed. This idea was pursued by Niall (1992), in an article on “Projective invariance and kinetic depth effect”. A first experiment established that there was “a reliable difference between the true cross-ratio and the estimated cross-ratio for some shapes in continuous rotation”. A second experiment showed that errors in estimate of the cross ratio depended on differences in standard shape and that errors of this magnitude were not present for objects that rotate in the picture plane. A third experiment extended to shapes embedded in dense patches of texture where it was again found that errors in estimating cross ratio occured with differences in standard shape. A fourth experiment showed that observers did not perform significantly worse when comparing complex solids at different relative orientations rather than comparing them side by side. These experiments challenged approaches to visual perception in terms of inverse optics.

**Constancies**

One set of illusions that have attracted a particular amount of attention have been those concerned with the so-called constancies. Berkeley (1709) drew attention to the problem of size constancy in his Essay towards a new theory of vision. Experimental studies began with martius (1889), Hildebrand (11902), Beryl (1926) with more famous versions by Brunswik (1929, 1933, 1934) and Thouless (1931, 1932) which were concerned with visual size, shape, lightness and colour. The work of Ames (1914, 1921, 1946), focussed attention on ambiguities and potential illusions arising from a perspectival image seen from a single viewpoint. He demonstrated that several configurations of lines could produce the effect of a perspectively convincing chair as long as the viewer was restricted to looking from a single viewpoint. Ames built a room which form a given viewpoint looked regular but was in fact considerably distorted. Cantril (1950), pursued these demonstrations. Schlosberg (1951), in a note concluded from these experiments that direct physiological clues (314) such as disparity and accommodation are relatively less important in determining depth perception than factors like knowledge, (true or assumed)
of the size of the stimulus object while, nonetheless, claiming that the problem could be reduced to the following equation: size of retinal image = size of the object/distance of the object.

Ittelson and Kilpatrick (1951), experimented with the apparent size of a watch-card-magazine in different contexts; pointed out that the apparent size-distance rule was too simplistic; that size constancy was related to apparent shape, orientation in space and possibly brightness and came to the interesting conclusion that we should:

define constancy behavior as the attempt of the individual to create and maintain a world which deviates as little as possible from the world he has experienced in the past, which is the only world he knows, and which offers him the best possible chance of acting effectively and continuing to experience the particular satisfaction which he seeks out of living.

This approach is perfectly sensible if it is applied in local terms. Problems arise, however, when it is applied on a national or international scale: it leads to the Hilton hotel type of mentality, whereby individuals assume that travel entails experiencing the comforts of home in a different time scale, which reduces the potentials of adventure to a bland, homogenized equality that one associates with stereotypical American tourists.

Ittelson and Kilpatrick (1951), summarized the main experiments that grew out of Ames work in Scientific American, namely, the Ames room, equidistant balloons the apparent size of which varied with different lighting, objects the apparent distance of which depended on sequence of occlusion and perceived effects of rotation of an anamorphic version of a rectangular window. They believed that their experiments demonstrated how (7) “the perceived is an inseparable part of the function of perceiving”. In a further article, Ittelson and Kilpatrick (1951), challenged the size-distance invariance hypothesis. This led Ittelson (1960) to emphasize the importance of context in a new branch of psychology called transactionalism. Ironically, while drawing attention to the need for context, Ames and Ittelson’s experiments continued to limit themselves to cases involving a single viewpoint. Not surprisingly the school as such was brief lived. At the same time it led to some useful reactions.

Wittreich (1959), in “Visual perception and personality” concluded that the Ames room could “reveal that the way in which we perceive the size and even shape of others is powerfully influenced by our emotional relationship with them.” He found, for instance, that newly married persons reported that their partner looked normal more quickly than a stranger and that observers witnessed less distortion in an anxiety-producing figure than in the normal one. Anstis, Shopland and Gregory (1961), reported in Nature a formula for measuring visual constancy in stationary or moving objects.

There were also studies on how instructions affect perception by Predebon, Wenderoth and Curthoys (1974), or Braden’s (19**), study how rotation of an Ames window affects perception. Gombrich (1960), was intrigued by the Ames experiments and Gombrich (1988), cited them as evidence that (8): “Alberti’s procedure rests on an assumption, the assumption that we have a prior knowledge of the shapes to be represented....As soon as this anchorage in reality is lost, the resulting painting could stand for an infinite number of arrangements out there.” In other words, the Ames experiments seemed to confirm the
potential relativism of perspective. As Veltman (1986), noted this claim only holds as long as one associates perspective with being limited to a single viewpoint. If an observer has the possibility of comparing the evidence from different viewpoints, discrepancies between an actual chair and fictive chair can readily be restored.

As noted earlier (see above p.), Ponzo had drawn attention to the paradox that the same bar seen in a different context could appear considerably larger. This problem was considered by Gibson (1950, cf. pl. 52.1), discussed by Gregory (19**), reviewed by Gombrich (1975), and taken up again by Maturana, Varela and Frenk (1972), who concluded rather dramatically (102):

> Perception and perceptual spaces, then, do not reflect any feature of the environment, but reflect the anatomical and functional organization of the nervous system and its interactions. The question of how the observable behavior of an organism corresponds to environmental constraints cannot be answered by using a traditional notion of perception as a mechanism through which the organism obtains information about the environment.

Epstein (1977), in one of the basic collections of essays on the constancies began with a historical survey in which he noted how the Gestalt school had focussed attention on the constancies (2): "Whereas the introspectionist [in the Leipzig-Cornell axis of Wundt and Titchener] tried to strip away the constancies so that the genuine core could be observed, the Gestalt psychologist considered the constancies in perception to be the primary data."

Epstein noted that the constancies entailed three key relationships in the analysis of perception: between distal and proximal stimuli, between proximal stimulation and perception, and between distal stimuli and perception. He identified three main approaches to theories of perceptual constancy: learning, algorithm and psychophysical. The (associative) learning approach, claiming that "constancy is the product of learning that begins at infancy", had been developed by Berkeley (1709), Helmholtz and his contemporary, Sully (1878), Taylor (1962), and most recently by Piaget (1969).

Although James (1890), espoused a different theory of learning his approach to the constancies was consonant with the others. According to Epstein the algorithm approach (11): "proposes that the visual system operates according to rules of processing that combine variables to generate constancy of perception," had been articulated by Kepler (1604), Descartes (1637) and in our century by authors such as Eissler (1933), Holaday (1933) and Klimpfinger (1933). A third, psychophysical (or proximal stimulus) approach, claiming that "perception is the direct result of invariant retinal stimulation", had been championed mainly by Gibson (1950) and Wallach (1939, 1948, 1959). In the latter part of his introductory essay Epstein reviewed early experiments in the field on whiteness constancy by Katz (1911), shape constancy by Thouless (1931) and speed constancy by Dembitz (1927).

One of the essays by Coren and Circus reviewed a series of basic geometrical-optical illusions (Mueller-Lyer, horizontal-vertical, Wundt, Ponzo, Poggendorf, Oppel Kundt, Ebbinghaus and Delboeuf) and concluded (278) that "even if we accept a constancy scaling component in some illusions no presumption can be made that all visual geometric illusions are caused by constancy mechanisms." Another of the essays by Day and McKenzie argued for the existence of constancies in infants thus providing evidence
in favour of the view that constancies are innate and not learned. The essays in the book that followed focussed on the algorithm and psychophysical or proximal stimulus approach, leading Epstein to conclude that (445): "their coexistence may be due too their potential for serving as complementary accounts." In his methodological considerations he drew attention to the need for sampling of stimuli, to problems with pictures as stimuli, temporal aspects of design and with instructions. He pointed to a need for more data, particularly with respect to dynamic stimulus situations (Johannson) and to neurophysiology, as well as a need for analysis.

Another proponent of the psychophysical approach, Wartofsky (1978, 27), building directly on the ideas of Gibson, argued that:

The traditional view -the theory of perceptual constancy- alleges that the visual system receives variables and perceives constants; that is, it constructs, by ‘unconscious inference’, or by some mental processing) a veridical picture or map of the external world, which is then imposed on the variations in the information which the flux of the reflected light presents. I argue, by contrast, that the visual system is already structured to perceive constants, and that the additional ability to perceive variations is an achieved one; that is; that we learn to make inferences to the variations in shape and form, and not from them; and that this ability derives form the theoretical analyses of vision, which are embodied in our canons of representation. It is therefore because we make pictures according to the rules of perspective, that we learn to ‘see’ the size and shape variations objects in the visual field....The visual field itself -the space of our visual activity and of our human practice which involves vision- is a construct which is ordered by our practice, in particular, by our practice of making pictorial representations of the visual world.

Such claims reflected a more general movement in the literature whereby psychological factors in perception were given greater attention. For instance, Postman, Bruner, McGuinnies (1948), in “Personal values as selective factors in perception”, explored the relation of value orientation and perceptual selectivity and concluded that value orientation (154): “makes for perceptual sensitization to valued stimuli, leads to perceptual defense against inimical stimuli and gives rise to a process of value resonance which keeps the person responding in terms of objects valuable to him even when such objects are absent from his immediate environment.” Jenkin (1957), in “Affective processes in perception,” reviewed literature on four factors: size judgment; physiological need in relation to perception; selective sensitization and reactions to noxious stimuli.

Gombrich (1985) of perception. Object vs. context cf. vision vs. representation

Nature of Pictures and Linear vs. Parallel Perspective

The study of monocular and binocular depth perception led Schlosberg (1941), to demonstrate that photographs can induce compelling and highly realistic impressions of depth when a viewer’s monocular field of view was restricted to a photograph. Smith and Smith (1961), examined photographs as distal stimuli for targets of tossed balls and came to five conclusions (232-233):
1) Photographs, when viewed appropriately, can serve as the distal stimuli for the motor response of tossing a ball to the distances of targets in the space immediately adjacent to a subject; 2) Restriction of the field of view of the viewing apparatus increases the extent of the perceived distances as defined by the motor responses; 3) Accommodation, convergence, motion parallax and binocular disparity do not have to be in correspondence with the distances to which accurate motor responses (target hits) are made; 4) Visual direction alone is an insufficient basis for accurate motor responses to the distances of targets; 5) Photographs may be a useful tool for controlling the light to the eye for the study of visual stimuli for perceptions of absolute distances.

As was noted earlier (see above pp. 100-104*), the debates between Gibson and Gombrich concerning the ontological status of perspective have raised afresh the whole problem of how pictures relate to the real world. Gibson claimed that we perceive pictures in a way that is fundamentally different from the real world. Gombrich by contrast insisted that we perceive both in the same way. Gombrich’s work prompted Perkins (1973), to examine how the eye compensates for distortion in viewing pictures obliquely. Perkins noted that there were two possibilities (13): “at one extreme the interpretations of an obliquely viewed picture might be *projective*, according with the image projected to the eye of the observer as though that image were seen perpendicularly: at the other, the interpretation might be *orthogonal*, according with a perpendicular viewing, no matter what the actual viewpoint”. Perkins linked Gombrich with the projective interpretation and offered what he believed was evidence that the orthogonal interpretation was true. This article was significant because it heralded attention to parallel perspective as a feature of everyday perception.

These debates also related to a larger discussion whether the information in a picture (be it a drawing, photograph or painting) has the same information for depth and surface layout as found in the environment. Schlosberg (1941), Gibson (1971), Kennedy (1974), and Hagen (1974), were among those who claimed yes for static situations but then raised questions concerning the role of motion. Hagen and Elliott (1976), examined preferences for viewing regular objects using both linear and parallel perspective from a) an arbitrary station point; b) a correct station point and c) an unconstrained station point. It was claimed that axonometric or parallel perspective was (487): “the most natural and realistic looking in all conditions” and found that persons preferred a distance at least ten times as great as the object was large. This was termed the zoom effect.

Various scholars, including Schlosberg, (1941), Gibson (1950, 1969), Gregory (1970), Attneave and Frost (1969), Yonas and Hagen (1973), had argued that pictures contained textured background or flatness information, whereas real scenes do not. These claims are of considerable interest because they help explain why the study of textured surfaces became such a popular topic among psychologists during the 1970’s. Hagen and Elliott (1976), found that adults chose as most natural and realistic, pictures which had a station point ten times the size of the depicted object as both Leonardo and Einstein had recommended. This problem was further explored by Hagen, Elliott and Jones (1978), who tested whether their zoom effect (i.e. preference for perspective convergence where the distance was ten times the size) was dependent on information specifying the flat surface of the plane of projection. Hagen and Jones (1978), found that this preference for
the zoom effect did not occur in 4-6 year old children. Jones and Hagen (1978), summarized these findings.

**Limits of Rules**

At the turn of the twentieth century, Zoth (1900), also known for his studies of apparent curvature of the heavens (see above p. 92*), made careful studies of the muscles used in changing the direction of the eyes. Building on these studies, Gutmann (1903), examined connections between direction of vision and judgement of apparent size, and concluded (343) that in viewing objects that were 25-36 cm. from the eye, when the angle of vision was greater than 40 degrees these objects appeared 3 1/2-3 2/3% smaller than when viewed directly.

Von Oettingen (1910), in an essay on “Determining perspectival Images with respect to the station point of the observer”, marked an early attempt to include psychological factors in the perception of perspective. So too was the work of Poppelreuter (1910), which has already been mentioned (above p. 94) with respect to problems of apparent curvature of images in the eye, and was cited in this respect by persons in other fields such as Panofsky (1927). Ovio (1910), examined problems of reading texts from an oblique position and the whole question of perspective when seen from a non-central viewpoint (pl. 53.1-2), problems subsequently taken up by Gombrich (1973), and related to what Kubovy (1986), termed the robustness of perspective. Adams (1972), relying on Carter’s methods of analysis, explored what happens when an observer strays from the expected viewpoint and concluded (217):

> The depth of perceived space falls short of that predicted by geometrical hypothesis. The results do not confirm current assumptions about the importance of the mode of viewing. Monocular and pin-hole viewing, although they may increase the likelihood that the viewer will experience a full illusion of space, do not increase the apparent depth of that space.

Arnheim (1977), returned to the problem of “Perception of perspective pictorial space” from different viewing points”, claiming that no particular viewing point is demanded by central perspective which led him to a provocative conclusion (288):

> By emancipating ourselves from the perspective represented in the picture, viewers are enabled to look into a world that is no replica of a possible spatial experience of their own but is another person’s subjective percept. The opportunity to look into someone else’s world from the outside (i.e. without adopting that view) can be offered only by a picture- the kind of picture that presents a particular individual outlook on perspective space.

Whereas Gibson’s studies led him to focus on information in the visual world, Kennedy has concentrated specifically on information in drawings, exploring minimal cues for general spatial effects and perspectival effects in particular. This led to new studies of the blind, examining to what extent they are able to recognize and to represent perspective. He found that some sense of perspective was present even in the congenitally blind, which led him to claim that perspective was innate rather than a culturally determined phenomenon: i.e. dependent on nature not nurture. This claim was consonant with other
studies involving perceptually impaired humans and animals as well as recent findings in anthropology (see above p. 181*).

Kennedy (1993), pursued these themes in a significant book on *Drawing and the Blind. Pictures to Touch*. His point of departure was to challenge a general assumption that touch is proximal while sight and hearing are distal. His work turned on the question (291): "How can people understand the meaning of lines as axes without the help of vision?" Following an approach found in earlier authors such as Diderot (299), Kennedy devoted a chapter specifically to perspective (180-215) and concluded (300): "The perspective geometry of the world that can be used to make outline pictures is largely the same for touch and vision, including matters of convergence, vantage point and occlusions." Kennedy also devoted a chapter to metaphor and claimed that the blind do not (299) "lump together both literal and metaphoric forms of depiction. The blind distinguish the two means of representation and resort to the metaphoric when literal depiction is unable to show a referent".

As Kennedy himself admitted, he was making (300): "claims about the properties of the human mind". This was important because it established that some aspects of perspective are much more fundamental than are generally recognized. They are innate, part of nature, rather than nurture. If this be true, the question poses itself: why then did perspective manifest itself only in some cultures and not in others? For the sake of precision two things should however be noted. First, scholars such as Kennedy make a distinction between an ability to perceive spatially and an ability to represent spatially and while it may well be true that there is an almost universal ability to perceive spatially, ability and even a desire to represent spatially are very much culturally determined.
Fig. 64. Drawings of tables by blind children showing some spatial sense from John M. Kennedy, *Drawing and the blind*, New Haven: Yale University Press, 1993, pp. 110, 111, 109, 115.

Secondly, Kennedy and his colleagues use the term perspective in a very general sense, which technically speaking should be termed proto-perspective. For although many of his examples provide some sense of depth and general diminution, not one of his many cases has ever produced a precise vanishing point integrating a series of lines systematically drawn in three, two or even one point perspective (cf. fig. 60).

**Developmental Psychology and Learning**

As noted earlier (see pp.87*), debates whether knowledge is innate (nature) or a result of experience (nurture) goes back to Antiquity and play a basic role in distinctions between empiricists and nativists. The nineteenth century brought a new experimental basis to these debates. Volkmann (1858), in a fundamental essay “On the influence of practice on the recognition of spatial distances” raised various problems that were subsequently cited by Gibson.
A fascination with developmental aspects of psychology goes back to a nineteenth century ontogenetic-phylogenetic analogy (see above p. 178), whereby development in a child was thought to recapitulate the evolution of culture. Baldwin’s (1894), *Mental development in the child and in the race*, was one of the classic statements of these ideas but, as we have shown, a number of disciplines contributed to these studies including ethnology, anthropology, sociology, psychology and philosophy.

The quest for standards in the testing of intelligence gave new impetus to these studies. Hence Binet (1890), experimented with the perception of lengths and numbers in children aged 2½ and 4. Giering (1905), and Beyel (1926), pursued these problems, concluding that children’s perception of these phenomena continued developing at least until the age of ten. But it was particularly Piaget (1936, 1937, 1947, 1956, 1975), who formulated what became the most familiar model of development in children and adolescents identifying five distinct stages (fig. 62).

Vurpillot (1961), asked children from 5 to 12 years of age to give measurements of shape constancy: one relative to perception, asking them to abstract from a series of variables the projection corresponding to the momentary aspect of the shape presented; the other relative to representation, requesting that they extract from the same series of variables the frontal parallel shape. It was found that:
1) difference in the slant of shape was taken into account only from age 7 and up
2) degree of constancy is no better for familiar shapes than for unfamiliar ones
3) prior to age 12, children cannot represent to themselves the fronto-parallel aspect of a slanted shape
4) with the perceptive instructions the degree of constancy decreases with age.

Willats, whose early work included a cursory account of drawing systems written with Dubery (1972), classified some of the basic types of children’s drawings (1984, 1985, 1987). Caron-Pargue (1985), focussed attention on ways children draw a cube and offered further types. Nicholls and Kennedy (1992), adopted one of these and five from Willats in creating their own list of ten drawing types. Their study suggested that (227): “younger children use a similarity geometry with feature based criteria while the older children and adults use a vantage-point geometry which includes direction based criteria”. They also found that in the case of both 14-15 year olds and of the adults over 80% produced a parallel-projection drawing. J. J. Gibson and his wife, E. J. Gibson (1955), reviewed the problem of perceptual learning and began by identifying two major camps (32):

To some it implies that human perception is, in large part, learned - that we learn to see depth, for instance, or form, or meaningful objects. In that case the theoretical issue involved is how much of perception is learned and the corresponding controversy is that of nativism or empiricism.

To others the term implies that human learning is in whole or part a matter of perception- that learning depends on comprehension, expectation or insight, and that the learning process is to be found in a central process of cognition rather than in the motor process of performance. In this second case the theoretical issue involved is
whether or not one has to study a man’s perceptions before one can understand his behaviour.

The Gibsons outlined two theories of learning: enrichment (or creative process) and specificity (discriminative process) theories of learning. The first entailed acquiring more memory images such that a context of memories accrued by association to a sensory core. In this view perceptual learning consisted of “experience becoming more imaginary, more assumptive and more inferential.” In the second approach learning was “progressively in greater correspondence with stimulation, not with less”; it became more discriminating rather than more imaginary, and consisted of responding to new variables of physical discrimination. Gibson and Gibson favoured this specificity theory of learning and described an experiment to test it.

E. J. Gibson and Walk (1956) experimented with rats to conclude that their visual discrimination was not nativist but affected by learning and experience. By contrast, a significant essay by Walk and E. J. Gibson (1961), made “A comparative and analytical study of visual depth perception”, involving “hooded and albino rats, chickens, goats, lambs, pigs, dogs, turtles, cats, monkeys and human infants” which suggested that: “motion perspective is more important than density perspective for the animals in which it was experimentally isolated” and concluded that “the results in general support a hypotheses of innate depth perception, though the presence of a certain kind of environment during growth may be important for late maturing animals.” Senden (1932) and Riesen (1947), basing their claims on experiments with chimpanzees, were more forceful in insisting that the long period of maturation was “essential for the organization of perceptual processes through learning.”

A mature expression of these ideas was found in a major book by E. J. Gibson (1969), entitled *Principles of perceptual learning and development* (1969). Gibson followed a particular American interpretation whereby Helmholtz was seen as a champion of the empiricist and Kant a key figure in the nativist traditon (cf. fig. 10 above and fig. 65). Her earlier discussions of enrichment theories was now subdivided into cognitively oriented and response oriented theories, whereas differentiation theory was now linked with stimulus oriented approaches.

<table>
<thead>
<tr>
<th>Cognitively Oriented</th>
<th>Empiricism</th>
<th>Helmholtz</th>
<th>Association Theory (Titchener)</th>
<th>American Functional Psychology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response Oriented</td>
<td>Nativism</td>
<td>Kant</td>
<td>Gestalt School (Koffka)</td>
<td>Perceptual Reorganization (Street, Leeper)</td>
</tr>
<tr>
<td>Stimulus Oriented</td>
<td></td>
<td></td>
<td>(Gottschaldt) (Braly, Djang, Henle, Hanawalt)</td>
<td>Yale School (Gesell)</td>
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<td></td>
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<td>Differentiation Theory (Werner)</td>
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<tr>
<td>Inference</td>
<td>Theories assuming Unconscious inference or problem solving</td>
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<td></td>
<td>Probabilistic Cue Theory (Brunswik)</td>
<td></td>
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<td></td>
<td>Transactionalism (Ames, Cantril, Ittelson)</td>
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<td></td>
<td>Formation of a Schema theories (Bartlett, Vernon)</td>
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<td></td>
<td>(Leontiev, Zaporozhets)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Motor Copy Theories (Piaget), (Bruner)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Improvement of Theory</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Discrimination and E. J. Gibson</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Additive Mediation Differentiation Theories (J. J. Gibson)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Behaviorists (Pavlov) (J. G. Taylor, Hebb)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 65. A classification of theories of perceptual learning according to E. J. Gibson (1969, 74). Cf. fig 10

In other classifications, the nativist school was often linked with a mental and cognitive tradition, whereas the empiricist school was linked with a physical and experimental tradition. In Gibson’s version there was, as it were, an intellectualization of the whole spectrum. Gibson also proposed a classification of five items that are to be perceived, namely: objects, space, events, representations (two dimensional drawings, pictures of things, photographs, motion pictures), and coded stimuli (symbols). Interestingly enough the great majority of Gibson’s examples focussed on representations and coded stimuli, i.e. on the abstract section of the spectrum.

**Perspective Taking**

The roots of perspective taking have also been traced back to Baldwin (1894). As Geulen (1982, 14), has noted, Edmund Husserl’s (1915), theories of intersubjectivity in philosophy came very close to the idea of perspective-taking and these were in turn one of the sources of Alfred Schütz (see above p. 206*), who identified this ability of taking the viewpoint of the other as a central phenomenon of sociology. George Herbert Mead, building directly on ideas of Hegel, is seen by many as the founder of perspective-taking. Mead (1913, reprint 1980), explored how each speaker also hears themself listening and can thus put themself into the position of the person to whom they are speaking. Mead (1934), examined this ability “to take the role of” or “put oneself in the place of” other individuals, concepts which became explanations of social cognition, communication and cooperation. Ultimately Mead believed that they also provided a context for understanding the social origin of the subject and their identity.

Piaget’s three mountain experiments (1937, 1947), which became famous in North America only after the English translation (1956), transformed this discussion. Unlike Mead who equated perspective taking with personal identity, Piaget suggested that egocentricism marked a first stage in the development of personality and that the ability to recognize a form using different viewpoints or perspectives marked an important
second stage in the emergence of personality. This ability to look at a given object from different viewpoints is now termed perspective taking. In Piaget's work it was closely linked with the concept of decategorization. In his view an infant began by being egocentrically fused with their environment. As the child learned to differentiate themselves from social and non-social objects in their environment they learned to deploy attention to all relevant aspects of a phenomenon under consideration. Piaget viewed this decategorization as basic for cognitive and social competencies. Perspective-taking used decategorizing skills to infer the psychological experiences of others.

The basic contrasts between the approaches of Mead and Piaget could be seen as reflecting subtle but basic differences between (U. S.) American and European concepts of personality. In the United States, personality is defined in terms of finding, being and asserting the self. In Europe, personality is conceived in terms of one’s ability to be non-self-centred and as selfless as possible. Hence, whereas individuals from the United States often see a need to show themselves as a power play, a European frequently shows his true power by becoming self-effacing and seeming merely to retreat. To a person from the United States this will appear as a retreat out of weakness. Basic actions are completely misunderstood because of fundamental assumptions concerning development of the individual.

In the United States, Flavell (1963) studied The developmental psychology of Jean Piaget. Flavell (1966), compared the development of role-taking and verbal communication. This led to an important study by Flavell (1968), on The development of role-taking and communication in children and a series of later publications and an essay by Kohlberg (1969) which extended Piaget's concepts concerning the reconstruction of developmental sequences into the realm of social cognitive abilities and moral judgements. Williamson (1975), linked perspective-taking with interpersonal communication systems. Selman (1976), building on concepts of Mead (1969a, fig. 67), explored parallels between perspective taking and the development of moral judgement and suggested distinct stages (fig. 68).

Russell (1975), studied ways in which three-dimensional models viewed from above, could help children in making, reading and using two-dimensional orthogonal maps. Susswein (1977), examined the development of perspective-taking in young children and proposed a model in four stages that emerged from the ages of three to eight (fig. 69). Susswein's second stage corresponded to what Flavell termed as level one perspective-taking in which a child is able to specify what another child sees, while Susswein's fourth stage corresponded to Flavell's (1974), level two perspective-taking in which a child is able to specify how another child sees.

Fehr (1977), explored the factors in overcoming spatial egocentrism and developing perspective ability and accepted Piaget's suggestion that hypotheticality played an important role in recognizing the "other". Meshongnek (1977), examined two criticisms that had been made of Piaget and Inhelder's theory of visual perspective: first, that children do not become aware of differences in perspective before 5 ½-7 ½ years of age (e.g. Borke, 1975), and second, that incongruity between the child and observer rather than inability to overcome egocentrism explained why young children cannot anticipate differences in perspective (Huttenlocher and Presson, 1973). Meshongnek's own work
suggested (1977, 95) “that even for children as young as 4-5 years of age, there is an awareness of points of view different from their own as well as an understanding that the exact appearance of an array changes as a function of the spatial position of the observer.”

Johnson (1978), challenged Piaget’s approach to perspective taking because it focussed solely on cognition while ignoring perception and art. Johnson experimented with four different situations: 1) real-real, where a child sees a real scene and chooses a correct perspective from real-scene alternatives; 2) real-picture, where a child sees a real scene and chooses a correct perspective from pictured alternatives; 3) picture-real, where a child sees a pictured scene and chooses a correct perspective from real scene alternatives; 4) picture-picture, where a child sees a pictured scene and chooses a correct perspective from pictured alternatives. It was found that situations two (real-picture) and four (picture-picture) had more errors than others. Vertical orientation was also found to have an effect. This posed questions concerning the use of pictures among young children.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Cognitive Stage</th>
<th>Spatial Relation</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>sensorimotor</td>
<td>topological</td>
<td>0-1½</td>
</tr>
<tr>
<td>2.</td>
<td>preoperational</td>
<td>topological</td>
<td>1½-4</td>
</tr>
<tr>
<td>3.</td>
<td>intuitive</td>
<td>topological</td>
<td>4-7</td>
</tr>
<tr>
<td>4.</td>
<td>concrete</td>
<td>projective, Euclidean</td>
<td>7-14</td>
</tr>
<tr>
<td>5.</td>
<td>formal operational</td>
<td>Riemannian space</td>
<td>14+</td>
</tr>
</tbody>
</table>

Fig. 66. Piaget’s stages of cognitive development, corresponding spatial relations and ages.

1. Knowledge of the subjectivity of perspectives
2. Reflective understanding of subjectivity.
3. Reciprocal perspective-taking
4. Perspective of a generalized other

Fig. 67. Stages of decentration in role-taking according to Selman based on Mead (1969a)

<table>
<thead>
<tr>
<th>Social Perspective Taking</th>
<th>Kind of Moral Judgement</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>0. egocentric</td>
<td>pre-moral</td>
<td>3-6</td>
</tr>
<tr>
<td>1. social-information</td>
<td>punishment and obedience</td>
<td>6-8</td>
</tr>
<tr>
<td>2. self-reflective</td>
<td>instrumental</td>
<td>8-10</td>
</tr>
<tr>
<td>3. reciprocal or mutual</td>
<td>reciprocal expectations</td>
<td>10-12</td>
</tr>
<tr>
<td>4. social and conventional</td>
<td>perspective of society</td>
<td>2-15</td>
</tr>
<tr>
<td>5. relativistic perspective</td>
<td></td>
<td>15+</td>
</tr>
</tbody>
</table>

Fig. 68. Parallels between social perspective taking and moral judgment at different ages according to Selman (1973, 1977).

<table>
<thead>
<tr>
<th>Claim made</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What I know is there.</td>
<td>3</td>
</tr>
<tr>
<td>2. What I see. What you see.</td>
<td>4</td>
</tr>
<tr>
<td>3. What I see. What we both see. What you see.</td>
<td>5</td>
</tr>
<tr>
<td>4. How I see it. How you see it.</td>
<td>6-8</td>
</tr>
</tbody>
</table>

Fig. 69. Four stages in the development of perspective taking according to Susswein (1977).

Marsh (1977), gave one of the best accounts of the key individuals and problems in the rise of perspective taking. Marsh noted that attempts to assert a single, global perspective-taking ability were being challenged by 1975 (Ambron and Irwin, Kurdek
and Rodgon) and that there was a trend to identify three distinct kinds of perspective taking in terms of seeing or perception; thinking or cognition and feeling or affective behaviour.

Perceptual perspective taking means children identify different viewpoints and coordinate them with their own: e.g. front-back, before-behind, left-right, that is, establish their position relative to other persons and objects. Marsh noted likely links between cognitive perspective taking and other cognitive processes such as linguistic ability (e.g. increasing use of verbal mediation), selective attention, perception, motivation, and memory.

So-called cognitive perspective taking, more frequently termed social perspective taking, means inferring the cognitions of others in social situations. To assess this some such as Flavell (1968), DeVries (1970), and Selman (1971), use games. One is asked to infer what a peer would guess or do in a given situation. Others, including Feffer (1959), Selman and Byrne (1974), use stories. One constructs a story and then retells it from the perspective of each character in the story. Feffer (1970), suggested three stages in the process of social perspective taking: 1) simple refocusing or simple perspective taking (age six); 2) consistent elaboration or sequential perspective taking (ages seven or eight) and 3) simultaneous coordination or simultaneous perspective taking (age nine). Earlier, Feffer (1959), had pointed out that social perspective taking is closely related to fields such as role-taking or role playing. Shaftel and Shaftel (1967), described this as (84):

<table>
<thead>
<tr>
<th>Perspective Differentiation</th>
<th>Perspective Taking</th>
<th>Perspective Coordination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recursive Thinking</td>
<td></td>
<td>Knowledge</td>
</tr>
<tr>
<td>Contiguity</td>
<td></td>
<td>External Characteristics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thinking About</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Action</th>
<th>Temporal Ordering</th>
<th>Causality</th>
<th>Interpersonal Relationships</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cause-Effect</td>
<td>Effect-Cause</td>
<td>Thinking About</td>
</tr>
<tr>
<td></td>
<td>One Loop</td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Alternation</th>
<th>Two Loop</th>
<th>Anticipation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thinking About</td>
<td>Thinking About</td>
</tr>
</tbody>
</table>

Reciprocity

Fig. 70. Oppenheimer’s model of perspective taking as outlined in Geulen (1982, 304).

the opportunity to explore through spontaneous (that is, unrehearsed) improvisation and carefully guided discussion, typical group problem situations in which individuals are helped to become sensitive to the feelings of the people involved, where the consequences of the choices made are delineated by a group and where
members are helped to explore the kinds of behavior that society will sanction. In this process, young people are guided to become more sensitive to the feelings, to the personal consequences of the choices they make, and to the consequences of those choices for other people.

Hence a variety of role-playing techniques have alternatively been termed perspective-taking (Chandler, 1973a), role-taking or role-switching (Iannotti, 1975a) and sociodramatic play (Rosen, 1974). Selman (1973), linked perspective-taking and role-taking more closely, identifying six stages in the process (fig. 63). It is interesting to note that a society can encourage role-playing and yet be taken aback when children then develop games such as Dungeons and Dragons.

Social perspective taking as an ability “to make accurate inferences about the psychological processes of others and to articulate and coordinate relevant perspectives” is seen by some as essential to social competency. Hence perspective taking has become linked with communication effectiveness (e.g. Alvy, 1968; Cohen and Klein, 1968); moral judgement (Kohlberg, 1969; Piaget and Inhelder, 1969); prosocial behaviour (e.g. Aronfreed, 1970; Barrett and Yarrow, 1976); popularity (Piaget, 1926; Chaplin and Keller, 1974) and the absence of perspective taking was linked by some to impaired social functioning (Feshbach and Feshbach, 1969). Others linked perspective taking and interpersonal problem solving (e.g. Batcheler, 1975) and impersonal problem solving (e.g. D’Zurilla and Goldfried, 1971). Marsh (1975), used a perspective training program to explore links between perspective taking and interpersonal problem solving and found, among other things, that persons with initial deficits in simultaneous perspective taking were not helped by the training.

Affective perspective taking involves an ability to make accurate inferences about another’s feelings and emotional states. There has been debate whether this requires only cognitive understanding or actual (vicarious) experience of those feelings. In the United States there has been a trend to emphasize cognitive empathy over affective empathy. Assessment in this case varies: a child may be presented with a story and a blank face that must be paired with an appropriate expression such as happy or sad (Borke, 1971).

Or they are shown slides and asked to identify not only the feelings of those in a scene, e.g. attending a birthday party but also to react personally: how do you feel? (Feshbach
and Roe, 1968). This has led to new trends towards affective education aimed at children’s development of humanistic values, altruism, sympathy and social awareness.

Perspective-taking is a fascinating concept especially when the goal is altruism and sympathy. Yet where persons in the United States may believe they can infer accurately the inner world of other persons, in some traditions, including Canada, one would usually never ask about their inner psychological states, it being assumed that to do so would be an invasion of privacy, that if a person wished to disclose these dimensions they would choose to do so. Some persons in the European tradition doubt that one could ever hope to do so “accurately”. Autobiography is treated with a certain scepticism even when it reaches the sublime levels of a James Joyce or a Marcel Proust. If such authors who spent a lifetime describing the incredible vistas of their inner worlds have difficulties, who are we as outsiders to assume that we could guess even the outlines of their inner experience? To assume that we know reduces the richness of others’ experience to the limits of our own.

It would be misleading however to conclude that perspective-taking was a habit developed in the United States and rejected elsewhere. In German sociological literature perspective-taking was accepted as a variable by Bertram and Bertram (1974). A German translation of Flavell et al. (1975), opened new discussions which were provided a theoretical framework by Keller (1976). In Berlin, Silbereisen (1977), founded a workshop on social cognition and moral judgment, activities of which were published in newsletter and subsequently published in book form by Eckensberger and Silbereisen (1980). Silbereisen (1980) argued that analysis of formal structure of perspectivity will not suffice theoretically for the understanding of the development of social thinking if it does not take into account an analysis of the various content areas towards which the social thinking is directed.

Wahlen (1980), in an unpublished dissertation (Berlin), distinguished persons as behavioural (handelnde) subjects, who in their own behaviour are linked to the behaviour of others and accordingly imbue their own behaviours with subjective meaning from persons as knowledge subjects, whose perspective is primarily that of an observer who seeks to organize given subject matters in an understandable, i.e. meaningful way.

In order to distinguish between different views of a subject required an additional moment of reflective distancing. Building on the distinctions between perspectival differentiation and perspectival-co-ordination by Feffer and Gourevitch (1960) and Selman (1976), Wahlen claimed that we need to recognize the differences in perspectives (perspective differentiation) and then to reflect about the possible behavioural (handelnde) strategies for conflict resolution and take into account the attendant consequences for those involved in the conflict.

One of the first attempts to study these factors more systematically was Geulen (1982) who edited an important collection of articles on Perspective taking and social behaviour. Following an introductory essay on a theoretical framework for classing perspective-taking within social behaviour, a second section focussed on the concept and theory of perspective-taking. A third section explored connections between perspective-taking and other variables. Finally a fourth section examined external conditions that underlay the development of a capacity for perspective taking. These included a
translation from the French of Piaget's classic article and translations of work by Flavell, Feffer, and Selman which had originally appeared in English. Perhaps the most complex theoretical model in this series was offered by Oppenheimer (Amsterdam) whose framework is outlined above (fig 70).

Edelstein, Keller, and Wahlen (1981) attempted to reconstruct the development of social cognitive processes both theoretically and empirically in a significant book edited by Geulken (1981) on Role-taking, Decentration and Social Understanding. Edelstein and Keller (1982) in Perspective and Interpretation. On development of Social Relations, in a fundamental work, set out to bring genetic structuralism and an interpretative experiential interactionism into the analysis of both competence models and the performance criteria of social thought in order that beyond the cognitive paradigm one would gain new perspectives for the understanding of egocentrism, decenteration and socialization of the consciousness. It was the first of a series devoted to the development of social understanding, interactive capacity, moral judgement and ego-development, which would include the collected works of Lawrence Kohlberg and a German translation of William Damon's The Social World of the Child. Kolberg 1974

Edelstein and Keller began by reviewing the development of social cognition, noting the seminal influence of Flavell et al. (1968). Piaget's work had made available a general theory for the development of cognitive processes into which it seemed possible to insert a theory concerning the development of social thought. Initially Piaget's research had focussed on cognitive egocentrism and invariance. Those who explored development of social thinking focussed on a shift from viewpoint fixed centric thinking to reversible thought processes in which relations could be internally co-ordinated.

The three mountain experiment in Piaget's writings (1950, 1975) became the basis for experiments to reconstruct social perspectives. Differences in social perspective were reproduced experimentally through different information about a given situation. For instance, in the work of Chandler and Greenspan (1972), a second figure was introduced into the action sequence at a later time. The problem was pursued by Edelstein (1975) and Flavell (1975) who removed images and thereby formed a sequence of images in order to produce different perspectives. Eckensberger und Silbereisen (1980) focussed on the ability to distinguish spatial-visual perspectives, which subsequently acquired a paradigmatic role in research. Ability to differentiate spatial visual perspectives thus acquired a paradigmatic role in research.

Piaget began from the premise that the process of explaining and understanding were synonymous, that no distinction was necessary between spatial-visual differentiation of perspectives and their interpretative reconstruction. He believed that the process of explaining the object world and understanding the personal world were synonymous. Hence he assumed that individuals' instrumental actions with objects revealed their stage of development. Various content dimensions of objects and relations of social cognition thus became the cause of shifts (décalages) in decenteration: i.e. in explaining earlier or later acquisition of social cognitive abilities. Edelstein, Keller and Wahlen (1981) were among the first to begin studying these distinctions systematically.
In an analysis of social understanding, Edelstein and Keller examined universal conditions for the constitution of the social world. They noted that Piaget did not distinguish between instrumental behaviour with natural objects and interactional behaviour with other behavioural subjects. By contrast, the work of Mead (1969a, 1969b) and Joas (1980) reconstructed the development of thinking from the perspective of a socially behavioral subject. Both Piaget and Mead shared a radical reconstructivist position whereby objects of knowing are not given realities in the world, they are constructions, arising from social behaviour in the world. For Piaget it was primarily the co-ordination of behavior (Handlungen) that led to development in a monological interaction. For Mead interaction was dialogical. Mead understood object constitutive behaviors as social interactions and thereby objects as social products, which in turn gained their shared meaning in the process of social interaction.

At the same time the social constitution of the object is only the other side of the constitution process of the subject. Since the meaning of objects came from this structure, it followed that subject and object are socially constituted in the same way and from the same origin. Through the ability at perspectival change, the interacting partners could agree about their actions and come to a common understanding concerning a behavioural (Handlungs) situation. Perspectivity thus became a central prerequisite for human behavior, which continued to be behaviour in symbolic interactions. Hence the process of role-taking thus lies equally in the knowledge of the object world and the understanding of the world of the subject.

While the general, instrumental intelligence developed in the process of interaction with the object world as a result of the invariance and predictability of objects, the social, communicative intelligence evolved in its interaction with the social world of subjects on the basis of the reciprocity of symbolic perspective exchanges of the person engaged in interaction....Thus the reflective self developed through the ability of changing perspective, which allowed the subject to see their own handling form the position of another. Thereby they were put into the standpoint of taking themself as the object of knowledge and gaining reflective distance to their [own] actions. Insomuch as this began the development of a system of social meanings, the symbolic changes of perspective also became the prerequisite for sociality and individuality.. and led to the development of an equally social and individualized I.

For Piaget it was primarily the co-ordination of behavior (Handlungen) that led to development. For Mead language played a major role. Communicative acts were therefore anchored in co-operative acts, i.e. in social behaviour and relations. The intersubjectivity of meanings sprang from a system of "universal socializing idealizations" as described in Schütz (1974) as well as in Schütz and Luckmann (1975).

Everyday Knowledge and the Meaning of Situation

Edelstein and Keller traced how these developments affected notions of everyday knowledge and the definition of situation, noting that Blumer (1969) had developed Mead's ideas concerning symbolic interactionism. In this approach the world was always interpreted: subjects defined meanings in the process of interaction. "Situation" in this case meant the process whereby the behavioral (handeln de) person reached an understanding of situations. The definition of situation included the understanding of self
and other, the understanding of behaviors, behavioral goals and behavioral expectations
both with respect both to the factual-descriptive aspect (what is) and the normative aspect
(what should be). The reciprocal coordination of behaviours was only possible through
the reciprocal interpretation of the partners interacting with one another through such
definitions of perspective. As Sprondel and Grathoff (1979) observed this had
consequences for both the observed (actors) and the observers (researchers).

A young child only had access to specific knowledge of given situations. Adults, by
contrast, used such specific experiences in the social world in order to develop more
generally valid, universal knowledge of the world. The various factors determining this
process were studied by Blumer (1973) and pursued by Schütz (1974) and Schütz and
Luckmann (1975), who pointed to the role of typifying (Typisierung). This entailed an
idealising assumption concerning the reciprocity of perspectives, mentioned earlier,
whereby an actor begins from the premise that if they were in the same position as
another actor, they would have the same perspective at their disposal. From this
assumption of reciprocity perspectives could become universal, objective realities. It
followed that there must be a trans-situational meta-knowledge about the perspectivity of
experiences that was independent of an given social situation, which served as a point of
departure for experiments by Chandler and Greenspan (1972). In adult life knowledge
concerning if-then situations could be either specific (particular) or general (universal),
the former aiding hypotheses that led to the latter.

Interpretative Paradigms and Rule-Bound Behavior

Ball (1972) described the process whereby the behavior (handelnde) of a person achieved
an understanding of the thinking of another person. He outlined a model of a naive
science of thinking whereby an actor used everyday theories concerning persons and
situations as a basis for hypotheses that were then tested, verified or rejected. Edelstein
and Keller distinguished between unproblematic behavioural situations which entailed
social scripts, i.e. scenes which unfolded as behavioral routines in interaction situations in
the sense of Abelson (1976), and problematic interactions where the approach described
by Ball came fully into play. Ball emphasized a constructivist approach: "To define a
situation is to engage in social construction of reality; since this process involves
knowledge it is the construction of social reality." This knowledge was sometimes
"knowing that" and sometimes "knowing how" and therefore tacit. It was therefore
important to distinguish between conscious cognitive knowledge about situations and
unconscious rule-bound adaptation of such knowledge in the behavioral process. This
helped to explain the findings of Piaget and others which showed that children often had
perspectival abilities long before they were verbally articulate about these abilities.

Turner (1976) suggested replacing Mead's concept of "role-taking" with "role-making" to
emphasize the role of the behavioral subject in social interactions. For Turner, the
process of role-making also entailed the attribution of goals and feelings. This included
the projection of distorted attributions (Habermas 1968, 1977), such as stigmatization
(Goffman, 1977), labeling (Sack, 1975).

Edelstein and Keller suggested that if one wished to organize the realm of social
cognition, i.e. of social understanding from a theoretical standpoint, it would be useful to
use three basic categories: 1) the description of concepts in everyday knowledge and their development; 2) studies on the social constitution and general mechanisms in the development of social understanding and 3) performance criteria for social understanding, which served as the basis for the three sections of their book.

Contents and Subject Specific Structures of Social Understanding

This focussed on psychological theories of everyday life which dealt with humans as psychic systems. This included naive theories of the self, others and relations between them. It also included everyday theories about social relations, behavior and behavioral regulations, with contributions by Damon, Furth, Secord and Peevers, Selman, Turiel, and Youris. It dealt in the broadest sense with descriptive categories for persons.

The early literature on developmental psychology focussed on persons as knowledge subjects rather than as behavioral subjects. Wahlen (1980) distinguished between persons as behavioural subjects and persons as knowledge subjects. This, he claimed, required classification and rule-systems and called for social cognitive decentration. Here Wahler defined two types: 1) a naive theory of interpersonal relations; 2) structurations of social content from different perspectives; that these perspectives imply different kinds of knowledge, of content. Only this second type of decentration lent itself to the development of perspective-taking. Using spatial-visual perspectives as an analogy, attention turned to social perspectives, i.e. the interpretation of situations which need to be reconstructed from the viewpoint of two or more persons. This required that a person being tested not confuse the information available from a given perspective: a process termed perspective differentiation. The literature on causal explanations of internal processes (e.g. feelings), explanations for the reasons of behaviours, and behavioural intentions was surveyed by Schantz (1975).

Perspective differentiation became the first step towards perspective co-ordination. Hence, having recognized the differences in perspectives, one then reflected about the possible behavioural systems for conflict resolution and integrated the consequences for those engaged in the conflict. Feffer and Gourevitch (1960) did preliminary work in this field. Selman (1976), along with Selman and Jacquette (1977), building on Mead had shown that there was a logical heirarchy of qualitatively different levels (figs. 68 cf. figs. 67,72) in the conceptualization of relations between the self (ego) and the other (alter). Geulen (1981) collected important essays and surveyed the literature on perspective-taking.

This work drew attention to different conceptual areas of social understanding, and a greater emphasis on the contents of social cognition. For instance, Turiel (1981, 1982), pointed to the subject specificity of social cognitive structures. Eckensberger and Reinshagen (1980) and Eckensberger and Silbereisen (1980) suggested a systematization of contents and realms of social thought in terms of behavioral theory such that cognitions can be seen as partial aspects of behaviour. This resulted in a matrix that derived, ultimately from Aristotle's concept of the four causes (fig. 67).

1. Causal explanations Motives, grounds
2. Final explanations Goals
3. Means  
4. Intended and unintended  

Realization  
Consequences  

Fig. 71. Four categories for classification of behavior according to Eckensberger and Silbereisen (1980).

Edelstein, Keller and Wahlen (1981) examined understanding of aggressive situations and sorrowful situations. Their book was an attempt to systematize social cognitive research with respect to a theory of social understanding.

Constitutive Mechanisms of Social Understanding

A second sociological section concentrated on knowledge of social relations, societal institutions and social rules; general mechanisms for development of social understanding with contributions by Peters, Voyat, and Keller. This included the cooperative and conflictual relationships among persons of the same age.

Performance Criteria of Social Understanding

A third, normative or prescriptive (moral) section, included contributions by Blasi, Döbert and Nunner-Winkler, Noam and Kegan, and Keller. For Blasi social concepts were a means of cognitive behavioral scheme, an approach that drew attention to social experiences in which the ability in perspective taking and the social knowledge of the person are acquired, particularly with respect to differentiated experiences.

Keller explored how the interactive function of the family reflected on both the genesis and the performance of social cognition. Keller showed that a theory of the social constitution of social understanding was also a theory of performance and conversely. A theoretical model required both universal and differential-psychological aspects in order to do justice to the integrity of its object.

Edelstein and Habermas (1984) noted that the constructivist approach of Piaget which was adopted in social cognitive research acknowledged a developmental mechanism that is equally determined by the individual activities of the person and by their position in the social system. To explain this theoreticians turned to Mead's (1934, 1967) interactionist model of competence acquisition. This led to connections with research into performance criteria of social cognitive and socio-moral abilities.

The authors noted that the validity of the structural models of development had become a renewed matter of debate, particularly concerning the relation of moral to social structures through Bertram (1978), Condon and Weiting (1982), Habermas (1976, 1983), Lidz and Lidz (1976), Lidz (1982).

1. theoretical formulations  
2. studies on development of interaction competence  
3. role of the self in social understanding

Forgas (1987)
Mezirow (1991) explored the role of perspective transformation in adult learning. He distinguished between two dimensions thereof: the transformation of meaning schemes, which he saw as part of everyday reflective learning and meaning perspectives, which entailed re-assessing basic premises and led to major life changes. Mezirow cited the general influence of psychologists (Chomsky, Piaget, Kolberg); sociologists (Habermas) and philosophers (Bateson, Cell). More specifically in psychology he reviewed the work of Bruner (1957) and Piaget's (1967) concept of decentration. With respect to development of cognitive structures he referred to Adorno's negative dialectics (Buck-Morss, 1987), whereby development involves achieving critical instability, as well as the ideas of Merleau Ponty as interpreted by Greene (1975) and Heron (1988). In sociology, Mezirow, cited Döbert, Habermas and Nunner-Winkler (1987), who argued that interactive competence, i.e. the ability to take part in increasingly complex action systems, is central to identity formation. Selman (1987) had described this in terms of three stages of role-taking, whereby a person learns (fig. 72):.

1. that others see the same situation from different perspectives and thus differentiate points of view
2. to understand its own intentions and behaviour from the perspective of others, thus making possible
   reciprocal perspectives
3. that those interacting can not only take the role of the other but also learn from the viewpoint of a third
   person how their own perspectives are reciprocally involved with those of the other.
Fig. 72. Three stages in the role-taking abilities of a child according to Selman (1987). Cf. figs. 67-68.

A review of perspective transformation in the literature of adult development followed. Kagan (1980), Favell (1982), and Kuhn (1983) as interpreted by Blanchard-Fields (1989, 92) and cited by Mezirow suggested that "there may be predictable orderly sequences of experience in adulthood rather than inclusive, shared internal or external structures." According to Mezirow, Lichtman (1987) saw the concept of developmental stages as capitalist ideology, while Fiske and Perlin as reported by Bee (1987, 73-76), failed to find widely shared psychosocial or psychological stages. Hence whereas earlier psychologists such as Erikson, Gould, Levinson and Piaget related developmental progress to specific ages in the life-cycle, Mezirow gathered seeming evidence that such a transition could take place at any point in adult life. This begged the question: what were the conditions that determined the equivalent of a conversion experience?

Mezirow found one answer in the work of Basseches (1984), who linked adult development and cognitive maturity with dialectical thinking. Basseches identified twenty four "schemata" or "movements of thought" in his underlying model of dialectic. Mezirow interpreted this model to mean "the inferential logic of transformative thinking". Accordingly Mezirow was able to take Basseches' nine meta-formal schemata (fig. 69) and his five criteria for comparing forms of thought (fig. 70) as a basis for establishing and comparing his own categories of meaning perspectives.
Having separated development from any specific age or period, Mezirow went on to argue that perspective transformation was identical with development. In defence he cited Perry (1970), Arlin (1975); Commons, Richards and Armon (1984), Broughton (1977) and particularly Labouvie-Vief (1984) who "most explicitly identified the central role of perspective transformation in adult development." Labouvie-Vief saw development as a two-phased process: 1) between birth and adolescence; 2) post-adolescence in adults. The theories of Labouvie-Vief and Blanchard-Fields (1982) were again cited with respect to perspective transformation in aging.

Mezirow also considered perspective transformation in life decisions. Here he cited the work of Sloan (1986, 107) to claim that psychological growth was not attributable to natural forces, and that persons left on their own "often take the turn toward addiction, masochism or suicide in the midst of transition periods". Sloan claimed that each of the seven stages in Brammer and Abrego's model (1981) were connected with both decision making and a way of coping. Mezirow noted parallels between this model (fig. 71) and his own (fig. 70).

He next considered four theoretical overviews of perspective transformation. A first of these built on the notion of lifeworlds used by phenomenologists. Wildenmeersch and Leirmann (1988), for instance, identified three stages: the self-evident, the threatened and the transformed lifeworld, each of which they related to a corresponding type of dialogue, namely, narrative, transactional and discursive dialogue. A second of these drew on Loder (1981), who identified five stages in his "grammar of the knowing event" (fig. 72) which he correlated with three orthogenetic stages, namely, notably differentiation, specification and integration. A third theoretical overview based on Mullins (1988) examined three stages in terms of pre-critical, critical and post-critical learning postures. A fourth theoretical overview based on the work of Boyd and Myers (1988) used a Jungian view to consider stages of discernment in transformation (fig. 73).

1. Location of contradictions or sources of contradiction within a system or between a system and external forces or elements which are antithetical to the system's structure
2. Understanding the resolution of disequilibrium in terms of a notion of transformation in developmental direction.
3. Relating value to a) movement in the developmental direction and/or b) stability through developmental movement.
4. Evaluative comparison of forms.
5. Attention to problems of co-ordinating systems in relation.
6. Description of open self-transforming systems.
7. Description of qualitative change as a result of quantitative change within a form.
8. Criticism of formalism based on the interdependence of forms and contents.
9. Multiplication of perspectives as a concreteness-preserving approach to inclusiveness.

Fig. 73. Nine meta-formal schemata or steps in dialectical perspective according to Basseches (1984).

1. Levels of equilibrium (inclusiveness, differentiation and integration)
2. Potential for contribution to development
3. Susceptibility of co-ordination with other forms, making them stable through developmental change
4. Practical change
5. Conformity to a masterform

Fig. 74. Five criteria for comparing forms (meaning perspectives) according to Bassesches (1984).

1. Shock and immobilization
2. Denial
3. Depression
4. Letting go
5. Testing options
6. Searching for meaning
7. Integration

Fig. 75. Seven stages of a life transition according to Brammer and Abrogo (1981).

1. Disorienting dilemma
2. Interlude for scanning
3. Constructive act of imagination
4. Release and openness
5. Interpretation of the imaginative solution into the original context by spelling out connections and seeking a consensus

Fig. 76. Five stages in the grammar of the knowing event or transformative logic according to Loder (1981).

I) Discernment
II) Receptivity or openness to the symbols, images and other influences of the shadow, anima, animus, persona and archetypal configurations
III) Recognition, awareness that an experience is authentic
IV) Grieving, a kind of talking back to the extra-rational message.
    phase 1) numbness and panic
           2) pining and protest
           3) disorganization and despair
           4) restabilization and reintegration

Fig. 77. Four non-rational stages in transformation according to Boyd and Myers (1988).

Phase I Generation of Consciousness
   Step 1: Encountering Trigger Events
   Step 2: Confronting Reality

Phase II Transformation of Consciousness
   Step 3: Reaching the transition point
      a) Decision to shift vision of reality
      b) Dramatic leap or shift that “just happens” in a way not consciously planned
   Step 4: Shift or leap of transcendence

Phase II Integration of Consciousness
   Step 5: Personal commitment
   Step 6: Grounding and development
Fig. 77. A model of transformation by Taylor (1989).
1. A disorienting dilemma
2. Self-examination with feelings of guilt or shame
3. A critical assessment of epidemic, sociocultural or psychic assumptions
4. Recognition that one's discontent and the process of transformation are shared and that others have negotiated a similar change
5. Exploration of options for new roles, relationships and actions
6. Planning of a course of action
7. Acquisition of knowledge and skills for implementing one's plans
8. Provisional trying of new roles
9. Building of competence and self-confidence in new roles and relationships
10. Reintegration into one's life on the basis of conditions dictated by one's new perspective

Fig. 78. Ten phases of perspective transformation according to Mezirow (1975, 1991).
1. Disorientation
2. Search for meaning and peace
3. Self-acceptance
4. Integration

Fig. 79. Four stages in perspective transformation according to Musgrove (1977).

Mezirow thus claimed that (155, 160-161):

Transformation theory is not a stage theory but it emphasizes the importance of the movement toward reflectivity in adulthood as a function of intentionality and sees it advanced through increased ability and experience, which may be significantly influenced by educational interventions....Perspective transformation involves an empowered sense of the self; b) more critical understanding of how one's social relationships and culture have shaped one's beliefs and feelings and c) more functional strategies and resources for taking action.

While this formulation may sound very reminiscent of the general developmental framework proposed by psychologists such as Blatt and Blatt considered earlier (cf. fig. 1), it is important to note that Mezirow has fundamentally shifted the meaning of perspective. It is no longer a personal point of view or vision of the world. Perspective is a strategy for action, for doing, it being implied that this means acting differently, doing something new, changing. Rather than being a method for standing back and viewing the world with greater distance, it is a means of tackling the world more directly. There is no goal of transcendence. The goal lies in change itself without, however, there being any clear criteria for when change is justified. Indeed having cited Sloan that natural change is not necessarily for the better, the implication is that we need to be guided in change. Perspective thus shifts from a challenge of personal insight to one of communal change.

Not surprisingly Mezirow related transformation to special settings such as a response to marginality and explored the role of collective transformations. He claimed that to raise consciousness in a group required (194) "acknowledgment of oppression, critical reflection on personal experience, the legitimation of personal knowledge and reflection on the mechanisms of power and equality among group members. He examined the role
of social movements in such transformations which led him to provoking conclusions (195, 224):

New social movements challenge the assumption that education should be used as a means to accomplish particular social goals. They redefine the purpose of education as personal transformation, which they see as the only way to assure cultural transformation and a better society....
The goal of adult education is to help adult learners become more critically reflective, participate more fully and freely in rational discourse and action, and advance development by moving towards meaning perspectives that are more inclusive, discriminating, permeable and integrative of experience.

**Conceptual Psychology**

Piaget’s (1948 etc.) studies of spatial development in children began as regular experiments as used in perceptual psychology. It was only in trying to explain the results of his findings that he focussed on cognitive aspects. Particularly in the United States, Piaget came to be seen as a proponent of cognitive developmental psychology. The applications of this developmental approach to anthropology and ethnography were explored by Werner and Kaplan (1956, cf. 1963). As noted earlier (p. 8-10*), Gablik (1975), and Blatt (1984), applied Piaget’s approach to art history.

Some would see these discussions as part of a larger trend towards conceptual psychology, basic to which is the assumption that development is a function of abstract, conceptual, mental processes rather than concrete, perceptual, visual experience. According to this interpretation the enormous literature on relations among vision, representation and reality, (considered in chapter three above), are irrelevant to problems of development. Many factors have played a role in the rise of this cognitive or conceptual approach. One impetus has come from philosophers such as Goodman (1969, xi) who used the concept of symbol as “a very general and colorless term” which “covers letters, words, texts, pictures, diagrams, maps, models and more”.

This approach undermined distinctions between visual images, which are based on the physical world and mental images, which are not. Structuralism, particularly as developed at Yale played a role. The rise of computers also played an important role. Kosslyn (1978), in an article on “Measuring the visual angle of the mind’s eye”, began by noting that (356-357): “Visual images are thought to be composed of representations like those that underlie our experience of seeing an object, and spatial information is supposedly represented in the same way in perception and imagination. If so it makes sense to think of visual images as having only a limited spatial extent”. Citing the work of Paivio (1971), Minsky and Papert (1972), and Pylyshyn (1973), he found evidence to support the claim that images embody spatial properties but noted that spatial representation in the human brain (388): “probably involves a more abstract isomorphism like that found in a computer representation of co-ordinate space”. He held that it was entirely possible that such images were partly generated from abstract propositional structures in long term memory.

These discussions entail an important debate about the nature of imagery: whether there are links between physical and mental imagery; whether there are connections between
external and internal images (see below). Pylyshyn (1973), revitalized anti-imagery arguments which were summarized by Kosslyn and Pomerantz (1973), and developed in a major book by Kosslyn (1980), on *Image and mind*, in which he claimed (27) that “images are not pictures. The simple picture metaphor is clearly inadequate”.

Kosslyn made significant claims about the nature of mental imagery, suggesting a two-tiered model whereby images were stored in abstract form in long term memory and then assembled for internal display in much the way that images on a television screen can be created from files in a computer memory. Kosslyn, who used information processing as a point of departure, developed a complex argument. He consciously rejected the resonance metaphor of the Shaw and Bransford (1977), neo-Gibsonian school, whereby the mind was (471) “likened to a tuning fork, which automatically responds appropriately to a particular stimulus configuration—without the necessity of a series for intervening processing stages”. Kosslyn formulated distinctions between propositional representation (description) and quasi-pictorial representation (depiction) in chart form (fig. 66).

<table>
<thead>
<tr>
<th>Propositional Representation</th>
<th>Quasi-Pictorial Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Description)</td>
<td>(Depiction)</td>
</tr>
<tr>
<td>On (Ball, Box)</td>
<td></td>
</tr>
<tr>
<td>1. Relation</td>
<td>1. No distinct relation</td>
</tr>
<tr>
<td>2. Argument(s)</td>
<td>2. No distinct arguments</td>
</tr>
<tr>
<td>3. Syntax</td>
<td>3. No clear syntax</td>
</tr>
<tr>
<td>4. Truth value description</td>
<td>4. Truth value only under particular</td>
</tr>
<tr>
<td>5. Abstract</td>
<td>5. Concrete</td>
</tr>
<tr>
<td>6. Not occur in spatial medium</td>
<td>6. Occurs in spatial medium</td>
</tr>
<tr>
<td>7. No abstract spatial isomorphism</td>
<td>7. Abstract spatial isomorphism</td>
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<td>a) No necessary part/whole relations</td>
<td>a) Necessary part/whole relations</td>
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<td>b) Size and orientation optional</td>
<td>b) Size and orientation necessary</td>
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<td>c) Arbitrary marks</td>
<td>c) Non-arbitrary marks</td>
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<td>8. No abstract surface property isomorphism</td>
<td>8. Abstract surface property isomorphism</td>
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<tr>
<td>a) No necessary part/whole relations</td>
<td>a) Necessary part/whole relations</td>
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<td>b) Shape not necessary</td>
<td>b) Shape necessary</td>
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<tr>
<td>c) Arbitrary marks</td>
<td>c) Non-arbitrary marks</td>
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Fig. 80. Properties of propositional and quasi-pictorial formats in Kosslyn (1980, 31).

By the time Kosslyn reached his conclusions it was clear that visual images were thoroughly subordinate to verbal images (456):

...imagery is a way of representing information that may be especially perspicuous for performing some tasks. Not all thought processes involve imagery, nor is imagery in a privileged position as a form of internal representation. The information represented in an image is defined only vis-à-vis the interpretive procedures that can be satisfied when applied to an image. That is, if there were no description of a rear tire, for example, an image could serve to represent the information that a car has a rear tire; an image represents some information only by virtue of the fact that interpretive procedures exist to ‘read’ a given spatial configuration as corresponding to an exemplar of some class. Thus we have attempted to study imagery in the context of a processing system, the whole of which defines how images can represent information.

Not surprisingly there were but ten figures, most of them charts, in this book of five-hundred pages. For according to Kosslyn’s model pictorial information per se was
ineffectual and presumably an illiterate mechanic could not learn about changing tires first hand.

These ideas were restated in a more popular book by Kosslyn (1983), *Ghosts in the mind’s machine. Creating and using images in the brain*, where he noted (xv):

A number of disciplines seized on the notion that mental functions could be studied independently of consciousness. Out of the melding of artificial intelligence (which is concerned with making computers behave like thinking organisms), psychology, linguistics, and philosophy has emerged the alloy known as cognitive science; and the methods and tools of cognitive science have allowed psychologists to bring scientific rigor to fundamental questions of the human mind.

What is intriguing is that these hypotheses about what could be the case are now treated by many as if they were undoubtedly so to the extent that individuals such as Crary are devoting their energies into reading into the evidence of nineteenth century sources the roots of this view: anachronism of a dangerous new type.

7. Psychiatry

The ontogenetic-phylogenetic analogy which led to exploration of analogies between development of an individual child and development of culture in general had its implications for abnormal psychology and psychiatry, as is clear from Réja (1907, 66), who noted in his *Art among the mad (L’art chez les fous)*: “Hence to follow the principal stages of the evolution of children’s drawings is to witness the progressive enrichment of its conscience in the gradual conquest of the universe that surrounds it”. Some researchers were particularly interested in what happened to a world view when a patient was mentally ill. For example, Mohr (1906), wrote an article “On drawings of the mentally ill and their diagnostic value” and Mohr (1909), wrote another on “Drawings of the mentally ill”. Prinzhorn (1922), in his classic *Representations of the mentally ill*, showed that persons with psychological disorders represented space differently than healthy patients and implied that inner space varied between healthy and ill persons. Meanwhile others continued to explore normal development. Dallinger (1928), wrote On the connection between the development of the consciousness of ego and children’s drawings and Sigg-Boeddinghaus (1929), published an article on “Drawing and painting and its significance for the spiritual development of the child”.

At the eighth congress for experimental psychology, Volkelt (1924), explored “Primitive complex qualities in children’s drawings”. At the ninth congress for experimental psychology, organized by Karl Bühler (1925, published 1926), Gelb published an important paper on “The psychological meaning of pathological disruptions of spatial perception”, a theme that was pursued in an article by Fischer (1930), on “Space-time structure and thought disruption in schizophrenia”. Scheller and Seidemann (1932), explored “The question of optico-spatial agnosie”. Rausch (1952), examined “Perceptual constancy in schizophrenia”. Tellenbach (1956), made a specialized study of space in persons who were clinically melancholic. These studies have led to special museums such as the Guttman-McClay Collection on the Psychopathology of Art (London) and a series of international congresses on psychopathological art. An article by Jacob (1963),
given at the third of these specifically examined characteristics of pictorial space and considered situations in which perspective was favoured.

Blatt, a Freudian psychiatrist, explored other aspects of these problems. Roth and Blatt (1971), found links between depression and a need to maintain volume representation, a theme developed in Blatt’s (1974), “Levels of object representation in anaclitic and introjective depression”. Blatt, Quinlan and D’Afflitti (1972), examined effects on psychological states of magnifying and diminishing of image size. Roth and Blatt (1974), further examined spatial representations and psychopathology. Blatt and Ritzler (1974), discovered correlations between suicide, representation of transparency and cross-sections on Rorschach tests. They also (1974b), found links between thought disorder and boundary disturbances in psychosis.

Brutsche (1976), using Jungian psychology as a starting point, examined The psychological significance of perspective in drawings of patients undergoing analysis. Brutsche examined the characteristics of linear perspective, diminution of form perspective (abnehmende Perspektive) and augmentation of form perspective (zunehmende Perspektive), noting how irregular use of the latter two separately or in alternation could be indicative of psychic disorders. He explored how reduced perspective could be a symptom of anxiety (Angst) and how the absence of vanishing points could be a symptom of feelings of dissociation. He examined disruptions in the spatial homogeneity and the objectivity of space as well as a reduction of a sense of distance and a lack of shadows in the drawings of schizophrenic patients. In the final part of his thesis he explored how patients with mental disorders tended to replace ordering based on perspectival construction by an aesthetic-rhythmic order.

Since 1950 research on inner space has gone in two very different directions: one, emphasizing links between exterior and interior space and stressing the importance of visual perception in the process; another minimising the significance of visual images and external physical space for inner images. The first of these trends has been particularly marked in Europe where psycho-linguists among others have found new evidence to claim that there are basic correlations between the space of the external world and the inner space of the mind. In the United States, some psychologists (with European backgrounds) such as Arnheim (1969), have made the bold claim that all our thought is Visual thinking.

At the same time, particularly in the United States, there has been an important trend to separate discussions of inner and external images. Kepler (1604), had a made a fundamental distinction between psychic, mental images (imaginines rerum), which are subjective and those images that can be physically projected onto walls (pictura rerum), recommending that one should focus attention on physical images. A key figure in this separation of external from internal images was Kosslyn (1978, 1980), whose ideas have already been considered above in the context of psychology. Meanwhile, Horowitz (1983), focussed almost exclusively on psychic images and classified no less than twenty three different kinds thereof (fig. 67).

Images Categorized by Vividness
1. Hallucination
2. Pseudo-hallucination
3. Thought image
4. Unconscious image
Images Categorized by Context
1. Hypnagogic or hypnopompic image
2. Dream image; nightmare
3. Psychedelic image
4. Flashback
5. Flickering image
Images Categorized by Interaction with Perceptions
1. Illusion
2. Perceptual distortion
3. Synesthesia
4. Déjà vu
5. Negative hallucination
6. After-image
Images Classified by Content
1. Memory image; eidetic image
2. Imaginary image
3. Entoptic image
4. Body image; Body schema experience
5. Phantom limb
6. Paranormal hallucination
7. Imaginary companion
8. Number and diagram forms.

Fig. 81. Four categories and twenty three types of images as classed by Horowitz (1983, 6)

This separation of external from internal and emphasis on inner images went hand in hand with a shift from a perceptual to a conceptual approach to thought, a new iconoclasm of the intellectual world, which had Yale as one of its centres. Complex individuals such as Blatt argued in favour of visual images while claiming that one needed a conceptual framework for their interpretation. Other Yale structuralists were sometimes less subtle. Since most of the protagonists of this conceptual approach came from a particular culture known for its iconoclastic tradition the question poses itself whether their analysis might not tell us more about their particular culture than about the basic nature of man.

Within the German context there has been a recent move towards synthesis.

Ciompi (1982)
L. Ciompi, Affektlogik, Stuttgart: Enke, 1982

Ciompi (1988)

Oerter (1984)
Silbereisen (1984)

**Time Perspective**

Frank (1939)
L. K. Frank, "Time Perspectives", *Journal of Social Philosophy*, vol. 4, 1939, pp. 293-312

Lewin (1982)

Wallace (1956)

Melges and Freeman (1977)

Schlosberg (1983)
A. Schlosberg, "Zeitperspektive als Ich-Funktion in der Schizophrenie", *Dynamische Psychiatrie*, Bd. 17, 1983, pp. 85-102,

Blankenburg (1991), in an important collection of essays entitled *Madness and Perspectivity. Alterations in Relationship to Reality of Persons and their Therapy* included writings by
V. Baeyer
Glatzel
Scharfetter
Knoll
Kraus
Benedetti
Winkler
Kuhn

In an epilogue Blankenburg (1991) made a fundamental distinction between perspectivism (*Perspektivismus*) and perspectivity (*Perspektivität*). By perspectivism he meant:

a position that emphasizes the being tied down to given perspectives in the sense of a dependence on the position of the subject (as one that is determined from before), and thereby accentuates the subjectivity of the subject. Accordingly, under
perspective we understand the limitation of human vision to perspectives, to perspectives as laid down rather than being determined by the position of the observer.

Often one does not give enough thought to there being a fundamental distinction whether the fixing of the stand- or view-point occurs a priori, that is, that it occurs independently of the subject or whether it is chosen by the subject and is changeable at will. In the latter case we are dealing with two variables which interact with one another, which thus excludes a unilinear causal nexus and thereby a simple determination, this all the more so because one variable is determined by oneself while the other is determined externally....

Accordingly perspectivity in contrast to perspectivism deals not only with the fixing of given perspectives, a fixing in which human as well as all other perceiving life forms are included. Perspectivity as we understand the the term here also encompasses the active, spontaneous perspectival changes, and, namely, not only the willfull, previously conscious, choice of perspectives aimed at given goals, but also the playful ones, the different perspectives that give accident a chance to play a role. The letting chance play a part serves here to exclude the subjectivity that enters in an a priori aiming towards given perspectives. The play, here the being able to play with perspectives, has in this context a particular significance. This arises (as paradoxical as it may sound), in that perspectivism (in the sense of the claim of a being fixed on a perspective), is removed precisely through a willfull, self-referential (in the highest potency, self-transparent) changing of perspectives in and through which the world becomes accessible to us.547

8. Linguistics

In the case of linguistics the entire early history of the field would again be beyond the scope of this essay and hence we shall limit ourselves instead to a brief consideration of Karl Bühler’s classic Theory of speech. The representational function of speech (Sprachtheorie. Die Darstellungsfunktion der Sprache, 1934), which introduced a new systematic framework for research. One of Bühler’s points of departure was to examine (36) the etymology of sign words (Zeichenwörter including Zeichen, sema, deixis, signum, seign), noting that these were all concerned with the realm of the visual, in the sense of brightness (Helligkeit) and visibility (Sichtbarkeit), namely:

making bright and visible and on the other hand placing in front of the eyes. Illumination (Erhellung) draws attention to itself; that which is presented before the eyes comes into the domain of perception. It is no doubt (to put it in plain German) the demonstration (uncovering) of things for the observer or conversely the leading of the observer ([i.e.] of the observing view) to things....548

Bühler explored the usefulness of Lessing’s comparisons between painting and language. He also drew attention to unexpected parallels between film and epic, noting that both involved a series of shifts from one viewpoint to another which he termed perspective jumps (Perspektivensprungen). He noted that films at the time had an average of 500 such jumps or shifts in perspective, and drew attention to the fact that Homer had used a similar method in his description of Penelope’s visit to the treasure room when she goes
to fetch Odysseus’ bow for the contest. But perhaps the most important consequence of Bühler’s extraordinary study has been the way it heralded developments in psycholinguistics.

The behaviorist school had assumed that children learned languages through imitation, association and reinforcement and were thus comparable to rats, who learned to run through mazes with the “aid” of reward and punishment. Experimental evidence established however that only about 20% of the words of a two year old reflected imitations and that by the time a child was three only 8% of their vocabulary was based on imitation. These findings effectively eliminated behaviorism as a valid explanation. Chomsky’s suggestion that there were innate linguistic patterns at play left open the question of how the potential was realized. Piaget’s studies offered one possible answer, and also led to new directions of research. One was to explore relationships between hearing and understanding, which led to new attention concerning the order in which persons explained things. Studies by Ullmer-Ehrich and Levelt (1980, cf. Bös ch 1981), at the Max Planck Institute for Psycholinguistics drew attention to the role of perspectival viewpoints in this process (5):

Local adverbs such as right, left, in front, behind, describe basic topological relations in (a) space. They belong to the so called “indexical” or “deictic” tools of speech. These point in their meaning to the speech situation in which they are expressed. In connection with this various anchorings in the situation are possible. Right can mean to the right of the speaker or to the right of the hearer. A (imaginary) walk can be described from a fixed point of observation or from the perspective of the person who is walking. In the first case the right/left orientation remains constant; in the second case it changes with every change in direction of the walking person. Moreover the indexical local adverbs, besides their situation dependent deictic function, also allow for a situation dependent intrinsic use in which the view or walking direction of the speaker or hearer plays no role. The speaker is now faced with the extremely difficult task not only of choosing an apt perspective but also of describing the chosen perspective unequivocally, thus avoiding perspectival equivocations and noting each change in perspective. One means that is often used to make the perspectival position unequivocal is to replace spatial deicta with temporal ones. (Hence instead of saying “At the wall with the window there is a table and to the left thereof there is a cupboard”, one says “At the wall with the window there is a table and then there is a cupboard”.549

Levelt’s studies suggested that descriptions of a model room entailed two basic patterns: one, right-right-right-right-below; the other, straight ahead, straight ahead, straight ahead, straight ahead, right. He claimed that subjects were at considerable pains to keep at a minimum the number of branch points since each of these changes of perspective rendered understanding more difficult.

11. Theology

Already in Antiquity there was a tradition that referred to the eyes as windows of the soul, thus linking vision with both the realm of the spirit and the moral world. In the mediaeval period, this evolved into a concept of moral optics which particularly favoured
the image of the mirror. A whole genre of literature evolved around *The mirror of the prince* (*speculum principis*).

In the first decades of the seventeenth century some authors in Germany continued this image as in the anonymous *Evangelical small perspective mirror* (1620). Others replaced the mirror with a perspective glass or telescope as in the anonymous *Perspective and conservative glass for blind Lutheran eyes* (1631) or the Swedish perspective through which one look into the hearts of the named Catholic and Lutheran regents and know how they are partially among and against one another and particularly how they feel and are inclined for good or evil against the holy word of God’s church and German freedom (1632). This image was extended to a secular context in the anonymous *Bellicose telescope, that is, a war perspective in which one can recognize what war is* (1652). A variant of this image spread to England where an anonymous supplement to a book called *A good souldier* was entitled: *A prospective glasse wherein the child in understanding is enabled to see what the wicked counsellors did above twenty years ago... with the help of chrystall spectacles [1644?]*, followed by *A prospective glass for Christians to behold the reigning sins of this age* (c.1688). In the United States, there was at least one book entitled *Prospect or view of the moral world* (1805).

Kaufman (1960), pursued these themes in *Relativism, knowledge and faith*. He distinguished between internal and external relativism (14):

> External relativism is the theory which claims to be based on what are supposed to be the results of objective, descriptive analyses of various historical periods of various cultures or of differing social movements or individuals within a given culture or historical period....It must either presuppose a standpoint (such as that of scientific method) which is assumed not to be historically conditioned, or it must establish the validity of its own standpoint by arbitrary fiat.

In order to avoid these absurdities of standpoint, he turned to internal relativism (15):

> Internal relativism grows out of the investigator’s attempt to “get inside” the strange culture, or historical period, or person he is studying, to such a degree that the strangeness of the customs and the ways of thought of the subject is overcome. The perspective from which the strange culture views reality gradually becomes a perspective which the investigator himself can assume, and as he is able to do this with increasing sympathetic sensitivity, he actually begins to apprehend the *norms* recognized from that perspective as norms, i.e. *in terms of their very normativeness*.

Kaufman was convinced that this internal relativism could not simply be dismissed and hence set out (22):

> to develop a theory of the knowing process which on the one hand, can do justice to the normative character of knowledge (and thus can account for its own existence without falling into logical and epistemological absurdity) and, on the other hand, can show how thought is bound to the concrete situation in which it emerges (and thus account for the relativity of perspectives and the apparent relativity of truth).
Schmitz (1977) explored these themes in The Godly and Space. Jones (1985), in an important book on the Logic of theological perspectives reviewed four Anglo-Saxon thinkers, namely, John Wisdom, R.M. Hare, John Hicks and Ian Barbour. He drew attention to patterns in time and the structure of temporal events in Wisdom’s (1944), Gods, and Paradox and discovery (1965). Jones examined the concept of view(s) in Hare’s (1955), Theology and falsification. Jones also compared the concepts of “experiencing as” as articulated by Hicks in Theology and verification (1960), and God and the universe of faiths (1973), with Barbour’s (1974), “interpreting as” described in Myths, models and paradigms (1974). Jones observed how the “as” aspect of experiencing and interpreting was an important expression of the human condition and related these discussions to debates concerning paradigm change in Kuhn’s (1962), Structure of scientific revolutions, relegating consideration of Kuhn’s (1970), Second thoughts to an appendix.

Part two was devoted to a linguistic analysis of perspectival discourse. Here Jones focussed on Wittgenstein’s concepts of aspect-seeing and world-views (see above p. 177). Part three focussed on three philosophical and theological applications of perspectival discourse: namely, Polanyi’s personal perspective as outlined in his Personal knowledge (1964); Kaufman’s (1960), historical perspective in Relativism, knowledge and faith, and Paul van Buren’s (1968), concept of story as the bearer of perspective in his Theological explorations and The edges of language (1972). Here Jones focussed on three points: the fundamental role of language in all human existence; religious discourse as a perspectival preoccupation with certain aspects of human existence and story as a bearer of faith and perspective. In the final part of his study Jones suggested that:

the story concept has an advantage over concepts such as history, myth, symbol etc. in that it allows a participation in a variety of overlapping semantic fields; that it points to a process of interpretation and a distinction between fictive and real worlds and that it brings to the foreground the actually used language as a natural phenomenon, i.e. as an expression of a way of life. This approach opens the way not only to biblical and church traditions but also to one’s understanding of oneself.

In suggesting that one’s life story could serve as a model, Jones was concerned with how this story could be accepted, modified, extended or denied. He was concerned with the logical space of human thought and action and it was specifically this logical space which he termed perspective. His final section set out to show that perspective in this sense constituted the fundament of our being and operational orientation (Daseins- und Handlungsorientierung).

12. Conclusions

Just as there are claims that linear perspective goes back to Antiquity, claims have been made that metaphorical uses of perspective in the sense of a viewpoint can be traced back to Antiquity and even as far back as Babylonian literature. We have suggested that these claims are mistaken: that in terms of visual images, Antiquity knew only optical adjustments and that in terms of verbal images, Antiquity may have been aware of
viewpoints, but that this was something very different from that which developed in the late thirteenth and early fourteenth centuries.

Elsewhere (Sources, pp. 183-185), we argued that there were not accidental parallels between a) Giotto’s new interest in realism that led to his illusionistic frescoes, in the positive sense, in Assisi, Padua and Florence; and b) Dante’s new interest in metaphor. In the opening chapter of this book we went further to suggest that the origins of both Giotto’s visual illusionism and Dante’s verbal metaphor lay in a re-definition of knowledge in the 1260’s first articulated by Roger Bacon under the patronage of the pope(s) at Viterbo. In this chapter we have suggested that this redefinition of knowledge led ultimately to both the origins of perspective in painting and the beginnings of an individual viewpoint in literature. We have shown, moreover, that both phenomena evolved slowly beginning from the mid-thirteenth and continuing directly until the mid-seventeenth century. The Annales school in France, as epitomized by Braudel, has insisted on a similar unfolding of history in the long term (à longue durée).

This has serious consequences for it means that most of our textbook generalizations which link the Renaissance, often specifically the Florentine Renaissance in the period 1400-1425, with the discovery of perspective and the birth of the individual (in the sense of having a unique viewpoint), need to be revised. What historians have persuaded us to have been a single event was a long process with a number of significant stages (cf. fig. 2).

If the practical development of the phenomena of perspective in painting and its verbal equivalent in literature was a matter of nearly five (mid-thirteenth to mid-seventeenth) centuries, serious reflection about its literary and philosophical uses only began at the end of that phase. Hence the very decades of the 1630’s and 1640’s in which Desargues was articulating the underlying principles of perspective, also marked when Pascal began to explore the value of perspective as a metaphor in philosophy, a theme continued by Leibniz and, as we have shown almost every major philosopher since. With respect to literature this process was equally slow. While Lessing touched upon and Goethe and Herder wrote extensively on the uses of perspective as a metaphor, it was not until the twentieth century that writers such as James, and theorists such as Lubbock, Lanser and Lintvelt, explored these implications in detail.

In other words, if the origins of perspective were a slow matter of five centuries, the discovery or uncovering of its implications has equally been a matter of the long term, in the sense of the Annales school. That which began in the seventeenth century has not yet ended. Hence while some would have us believe that perspective died in the twentieth century, it could more reasonably argued that the twentieth century has been the first to study in detail the deeper consequences of perspective. And while some would have us believe that perspective was in some mysterious way necessarily linked with the invention of printing, or rather the particular kinds of print culture that evolved in the Renaissance, we would argue that the advent of electronic media are bringing into focus for the first time some of its more dramatic consequences.

We found that what applies to both the uses and understanding of perspective as a metaphor in literature, applies equally to philosophy and theology. Here too awareness of the implications has been very slow, beginning in the seventeenth and gradually
gathering momentum until serious studies evolved in the twentieth century. There is yet a third parallel to be made. For, in our study of the history of bibliographies of perspective (fig. 9), we learned that this also was a slow process that evolved from the early seventeenth through the twentieth centuries, and that it was only very gradually that scholars became aware of the need for detailed bibliographic records. We noted that this process has not ended, that even now our methods for recording the past are being refined. We also observed on more than one occasion that a more detailed understanding of the past only became possible as these methods for recording the past improved: that a refinement of the tools changed the criteria for evidence in discussing the past and conversely.

These parallels are not co-incidental. Those aware of and concerned with perspective both literally and metaphorically are also concerned with an historical approach, which emphasizes the importance not just of texts but all evidence of the past. The study of space leads also to the study of time. By contrast those who would have us believe that “it’s history” simply means something is finished, passè, and useless; those who would have us believe that only the now counts, that eternity is only in an instant that is timeless or that the timely is more important than time, are precisely those who wish to convince us that space in the perspectival sense does not count, that the particular which changes with time and space does not count and ultimately that it is only universals which matter.

From this emerge two fundamentally different approaches to the world. One which searches for the eternal and enduring in those things that last over time and space. In this view, space is used to record objects, and time (history) confirms that which is enduring, confirms the value of a text, a painting or other monuments. So sources are important. This approach records changes in time and space but yearns for the unchanging. Hence, objects such as Greek temples become symbols of the lasting. The other approach seeks the eternal in the ephemeral, the moment, the now. In this approach, space is used not to record but rather to transform, alter and edit objects, while time (history) subverts the value of a text, an image or any object, which seemed enduring. The fact that a text of Hamlet undergoes different interpretations in the course of centuries is used as proof that one cannot rely on an original “source”, but must privilege equally all editions. This approach tries to capture the now in a note, a dance or a performance and searches for what does not change with time and space in logic, structures, principles. Paradoxically those who emphasize the fleeting moment also champion the universal, the archetypal and the gestalt. The first approach emphasizes content: the second focusses on form.

The consequences of these different approaches are profound. They affect definitions of what visual means, what history is, where truth lies and the very meaning of knowledge. The first approach insists that the visual is separate from the verbal, because it recognizes that the visual allows a one-to-one correspondence to nature, in the recording of particulars. Hence the visual corresponds to what is seen, or at least can correspond to what is seen. When it does there is knowledge. The second approach speaks of the visual as if it were like the verbal and will thus refer to visual language, visual grammar, visual logic and propositional representation as superior to quasi-pictorial representation (cf. fig. 66). While speaking of the visual and visualization, the proponents of this school mean that which cannot be seen, that for which there is no one-to-one correspondence to nature.
The first of these approaches emphasizes the importance of history, the second denies history and tries to convince us that everything is news: that news is not just something to be seen or heard once a day, but rather something that can be continuous through a news channel. And paradoxically those who emphasize news are constantly reporting on the importance of structures of and patterns in groups, masses, movements, societies, whereas those who are historical focus on the role of individuals and personalities, the single, separate, specific, distinct, particular, personal, distinctive and definite as opposed to the communal, collaborative, general, and politically correct, i.e. that which fits in with and so blends with the mass as to be indistinct, indefinite, and impersonal.

All this may sound slightly familiar. It should. Earlier in this chapter in our discussion of developments in sociology, a contrast was made between traditional and social perspective (fig. 68). Traditional perspective emphasized the individual, where social perspective focussed on the group. Traditional perspective insisted on quality, being independent, privacy, a particular viewpoint, inner worlds, levels of meaning, spiritual gain, being a-political, content, knowledge as facts, truth, being and substance. By contrast, social perspective argued for quantity, being inter-dependent and collaborative, no sense of privacy, consensus, exterior worlds, levels of discourse, material gain, being politicized and empowered, form rather than content, knowledge as construction and interaction, agreement rather than truth, seeming rather than being, illusion through image rather than substance.

The first approach accepts that there are objects, that there is “reality” and that truth and knowledge are discovered in time and space. Hence truth and knowledge deal with sources, with things that are real. The second approach challenges the value of words such as objects, reality, truth and even knowledge, arguing that whatever is valuable lies in the now, the momentary, the fleeting. Opinions differ as to what this means. Some claim that the now can include unchanging structures: logical principles, mathematical formulae. Others conclude that only performance is therefore of value: so the now is reduced to a film, a television program, a play, a dance, a concert, or in its most extreme form to fleeting dance movement, an ephemeral note. Hence truth and knowledge, to the extent that it even makes sense to speak of them, lie in abstraction and in performance. The first approach finds knowledge and truth in static, concrete things: the second approach argues that, if they exist, they are to be sought in abstract concepts and dynamic acts (musical, theatrical). The first emphasizes content. The second emphasizes form.

Perhaps it is no co-incidence that these two conflicting approaches underly many of the debates concerning the so-called information highway, in which some emphasize information (content), while many emphasize the highway, in terms of pipelining (form), such that the medium is the message in a new sense.

These contrasts are more than a snapshot of two passing stereotypes of “everyman” or “everyperson” as we find him and her on the street today. They reflect a much more profound pattern or struggle that has to do with our basic conceptions of knowledge: a new version of the struggle between universals and particulars. In our analysis we examined the study of perspective in a whole range of disciplines which, on the surface, were tremendously disparate, namely, ethnology, anthropology, psychology, psychiatry, linguistics, and sociology. At another level these are precisely the so-called disciplines.
which have been taken over by those who are champions of the universals as opposed to the particulars. Initially this was reflected in the actual name of their school: they were structuralists. In the meantime their names try to undermine their roots: they are post-structuralists, post-post structuralists, constructionists, de-constructionists, re-constructionists, even post-modernists.

They emphasize the importance of concepts over percepts; conceptual versus perceptual knowledge; abstract ideas over concrete experience. They speak of virtual as if it were reality itself. They pooh-pooh as retrograde anyone so naive as still to believe in realism in any form. They refer to scholarship as if it were another branch of the news. They constantly emphasize the latest findings and describe as utterly out of date and not with it someone who dares to cite an article or book written more than a decade ago.

It is not surprising therefore that this approach emphasizes psychology, sociology, and politics, which they call a science (political science), while trying to undermine the study of history (time) -- except of course their own--, and geography (space), in its physical sense, although they emphasize abstract, conceptual aspects of space. In this approach, subjects which are firmly rooted in reality are not really subjects. Forestry, for example, is a field that can be eliminated. Experiments which emphasize the links with a physical world are thus also suspect. So experiments with real mice in psychology can be replaced by simulated mice, and students can be led to make conclusions about the limits of the “real” world on the bases of limited simulations imposed by instructors. Experiments with real cadavers in medicine can be replaced by virtual cadavers, which do not stink and will give students a more comfortable, regular and regulated view of the body. Experiments in physics and chemistry can increasingly be simulated. The world to be studied is a simulated world, not the physical world. The inconvenient exceptions to the rule, the challenges of understanding individuals who do not fit the pattern can be eliminated at best, or relegated to minorities which, rhetorically at least, have equal rights.

On the surface the second of these approaches is winning. Hence the change in subjects in our schools: the new emphasis on process, on performance, on form rather than content. Hence a tremendous attention to the information highway where the emphasis is only on the highway. Hence an insistence on transforming everything into something virtual: virtual classroom, virtual (space) university, virtual resource centre, virtual museum (now something quite different from the phrase coined by André Malraux), and even, or especially, virtual reality. Hence the undermining of time and space in the curriculum, such that history and geography are given less significance, or are carefully re-written to reveal progress in terms of moving towards abstraction. The twentieth century is described in terms of the death of perspective (cf. fig. 1). As a result, abstract art and quantum physics gain new significance. And there is a curious downplay of experience in teaching while emphasizing the importance of schooling, practice, performance; which in turn reflects the current fashion in business and in the workplace. Theories of truth and knowledge are not as abstract as they seem. They affect everything that we do.

It is vital that we recognize that these two approaches represent fundamental aspects of the human condition, that it is not a question of the one winning or the other losing, but
rather a challenge of both complementing one another in the way that male and female, yin and yang do. We need certain persons to focus on knowledge and information in the sense of content, while others work on form, in the sense of pipelining or the highway. Else the information highway will be an empty and a dead end road. Evolution is embracing not replacing. So the history of perspective as a metaphor is much more than a turn of phrase. It takes us into the central problems of learning and being, today and in the future. The origins of perspective came about through a re-definition of knowledge. If the one-sided approach to knowledge that has gained the upper hand continues to gain dominance, then more than the end of perspective is at stake. Perspective is not just linear. It is a central phenomenon.
VI. TRANSFORMATIONS

1. Introduction

What has happened to perspective in the twentieth century? What are the present trends? In the first decades a number of famous artists abandoned traditional spatial techniques and experimented with new forms of art: cubism, expressionism, abstract expressionism. Some critics believed that these experiments heralded a new period of non-figurative art. For instance, Novotny claimed that scientific perspective had ended with Cezanne. Arnason, in his standard history of modern art, spread this view that perspective had died in the early twentieth century.

In retrospect it is clear that non-figurative art has become a new alternative rather than replacing all the earlier goals of art. Realism has not died: it has taken on new forms: including surrealism, hyper-realism, and super-realism. As a result, although there was a significant drop in the publications on perspective from 1914 to 1945 (during and between the two great wars), since then the number of books on perspective has continued to rise. Indeed more books have been published on the subject in this century than during the fifteenth, sixteenth and seventeenth centuries combined (fig. 82).

![Graph of publications on perspective in the twentieth century.](image)
There are a number of reasons for this rebirth of perspective particularly in the second half of the twentieth century. The enormous rise in world population has brought a hitherto unprecedented emphasis on the built environment, with a corresponding rise in publications on architectural perspective and technical drawing. Related to this has been a dramatic rise in the fields of surveying and mapping culminating in the emergence of Geographical Information Systems (GIS) (pl. 93-94) and Area/Facilities Management (AM/FM) in the context of public administration at the town, municipal and provincial levels, concerns with law and order (police departments) and security (insurance companies) (pl. 95-96).

New technologies have played an integral role in these developments. In the course of World War I the introduction of aerial photography brought new challenges of relating terrestrial maps with aerial photographs often taken at an angle and led to the new field of photogrammetry. The rise of satellite photography added an unprecedented quantity of raster images such that even today only an estimated ten percent of all satellite images are ever examined.

Integrally connected with this quest for recording the world has been a quest for reconstructing it electronically in terms of vector images. The discovery of basic algorithms for perspective in electronic form led to computer graphics and the emergence of the so-called four C’s, namely, Computer Aided Design (CAD), Computer Aided Engineering (CAE), Computer Aided Manufacturing (CAM), and Computer Integrated Manufacturing (CIM), each of which assumes the use of systematic spatial co-ordinates in the rendering of objects and contexts. This has expanded greatly the use of linear and other forms of perspective because once an image has been rendered in vector form it can be rotated, tilted and viewed from any direction either in its true dimensions (e.g. ground plan, elevation) or perspectively.

Analogue cameras are increasingly being replaced by both digital cameras and by virtual cameras: i.e. where computers reproduce the effects of a photographic image through graphics software. This is leading to ever greater links between analogue and digital methods in terms of vector and raster images. Cinema, as an application of photography, has also implicitly broadened the scope of perspective. New explicit uses for perspective have been introduced by set designers who replace actual cityscapes with illusionistic painted facades in order to save money, adapting techniques of accelerated perspective used from stage scenery in the theatre. Some of these dramatic effects have become permanent fixtures in theme parks such as Disneyworld and Universal Studios (Orlando). The emergence of virtual reality is a further stimulus for this resurgence of perspective, because it entails a combination of different viewpoints (see p. 237-239 below). For the purposes of this chapter, developments since 1950 will be referred to as modern perspective and will be compared and contrasted to Renaissance perspective where appropriate.

It is well known that Renaissance artists made copies of paintings. They also copied individual elements and motifs of paintings such that a hand from Leonardo’s Last Supper was used in a painting of a Virgin and Child. In modern terms they introduced the equivalent of clip art long before the notion was formally introduced. Twentieth century perspective has seen the adaptation of these elements and motifs in new contexts. For
instance, fifteenth century artists such as Piero della Francesca and Leonardo da Vinci revived an interest in regular and semi-regular solids. Modern artists use these shapes in holographic art. Euclid, in his *Elements*, described the construction of a seventy two-sided figure. Leonardo da Vinci, included this figure in his illustrations for Pacioli’s *Divine Proportion* (1496-1499, printed 1509). It was taken up by Fra Giovanni da Verona in his inlaid wood panels (intarsia) in Santa Maria in Organo, was a symbol for perfection in the Renaissance and became a recurrent theme in perspective treatises by Jamnitzer, Sirigatti, Dubreuil and others. In modern perspective, Salvador Dali adapts a variant of this seventy two-sided figure in a painting of a woman’s head. Other semi-regular solids found in Jamnitzer, recur as garden ornaments in a book by Nielsen (1812), and recur in variant form in Escher’s famous engraving of a *Waterfall*. Similarly, a cylindrical shape or toroid, known in the Renaissance as a *mazzocchio*, which became a leit-motif in Barbaro’s *Practice of Perspective* (1568), recurs in variant form in a woodcut by Escher. While the shapes are similar their function changes. During the Renaissance colour and shading were used to distinguish clearly between different sides and layers of a solid or series of nested solids. In modern perspective, artists such as Escher deliberately use colour and shading to introduce ambiguities in our reading of such shapes.

This continuity of images extends to other objects such as stairs, which are an important theme in the treatises of Jan Vredeman De Vries, and are said to have inspired at least one of the staircases in a painting by Rembrandt. In the twentieth century this theme of stairs continues in the famous staircases of Escher. Individual elements also recur in new contexts, as with the perspectival dragon in Uccello’s *Saint George and the Dragon* (London, National Gallery), which recurs in one of David Hockney’s stage sets. Or individual elements are substituted, as with the protagonist in Botticelli’s *Birth of Venus* (Florence, Uffiizi), who is replaced by Elvis Presley in Richard W. Maile’s adaptation (Siggraph, 1990). Sometimes the adaptation is merely a small part of the original as with the hands in Michelangelo’s *Creation of Man* (Vatican, Sistine Chapel), which recur in variant form in *E.T*. Hence while there is a continuity of objects and motifs a two way process transforms the Renaissance examples into modern ones. Objects which were originally isolated figures during the Renaissance become integrated into complex scenes in modern perspective. Alternatively, objects which were originally integrated in a scene during the Renaissance recur either as isolated objects or in new contexts in the twentieth century. This is one of the sources of the fragmentation of illusion considered below (p. 240) and is important because it means that the problems associated with electronic image editing packages were pre-figured by Renaissance artists.

As we have shown the origins of perspective were closely linked with the camera obscura, the mirror and the window. The camera obscura, serving as a pinhole window, enabled one to have an image of the outside world inside a darkened room. For Brunelleschi, both the pinhole and mirror served in the process of observing the finished perspectival drawing. In the case of others, (cf. Sources, pp. 142-145*), we have shown know that instruments such as the camera obscura, mirror and window also served in the production of perspectival images. Theoretically these instruments were equally suited in the recording of both exterior and interior space. In practice they became associated in particular with interior space.
2. Contained Spaces and Artificial Reality

Indeed, there is a striking way in which the mastery of space leads also to its enclosure. The earliest examples of proto-perspective are linked with the Greek stage at the time of Aeschylus. In early theatres such as Epidaurus the man made building was very much linked with the natural surroundings and the stage occupied but a minute proportion of the view. In later theatres the proportion of the stage increased relative to the rest of the structure, witness Delphi, the Odeon on the Parthenon, Segesta, etc. In subsequent Greco-Roman examples such as Taormina, the man made stage competed with the natural horizon. In the Roman era the stage became a frontal scene (*scena frons*), which blocked off everything from the eye level of the top seats downwards as in the theatre of Marcellus in Rome or the striking theatre at Aspendos on the South coast of Turkey. It was in these theatres which most blocked off the natural world that the Romans developed their striking proto-perspectival experiments in space which were then translated into the entirely closed spaces of their villas at Herculaneum, Pompeii and Oplontis.

It is noteworthy that medieval mystery plays at York or the later ones at Oberammergau which maintained the tradition of an open air context were largely uninteresting as far as their spatial representations were concerned. Indeed scholars such as Mesnil have argued that it was precisely this tradition of mystery plays that constituted one of the major points of resistance to linear perspective. The viewer’s attention was focussed on the players, without distractions from the scenery, a characteristic that continued into Elizabethan theatre, particularly Shakespeare, where the visual context was removed entirely, or rather interiorized, such that the words “painted” their own scenes and vistas.

In Italy, theatre developed in different ways. Saint Francis and his followers, not content merely to read and believe the written stories of the *Old* and *New Testaments*, insisted on acting them out, such that the great frescoes at Assisi were much more than interpretations of text with an unprecedented amount of realism. They were records of text that had become live theatre, theatre now in a sense where the acting was not play acting but life itself, where all the world was literally a stage. Instead of the traditional oppositions between scenes prefiguring the life of Christ (in the *Old Testament*) and the life of Christ (in the *New Testament*), the opposition was now between the life of Christ and the life of Saint Francis. In England the stage often remained in the open. In Italy, there occurred a curious enveloping process that was at once interiorizing. The little chapel that Saint Francis built, (the Portiuncula) was enclosed by an enormous church. In Italy, the mystery plays took place in churches. The new scenes were also recorded within the closed walls of a church. So too were the earliest perspectival paintings such as Massaccio’s *Trinity*.

In Greece, the spatial scenery of the theatres involved a public event that was sacred and included the entire community of citizens: in ancient Rome, these scenes moved increasingly into the private context that was secular. The Renaissance witnessed a similar pattern. Initially the spatial effects of proto-perspective were used in a sacred context on the walls of churches in theory to be seen by everyone. This was the case in Assisi. But from the time of Giotto’s frescoes in the Arena Chapel (Padua) and in the Peruzzi Chapel (Florence) the sacred spaces were connected specifically with private families, usually
newly rich. This was the case with Masaccio’s *Life of Saint Peter*, the first perspectival fresco cycle in the Brancacci chapel and remained so for most important cycles. The *Life of Saint Steven and Saint Lawrence* commissioned by Pope Nicholas V was for a private chapel in a section of the Vatican not open to tourists at the time. The same was true for Leonardo da Vinci’s *Last Supper* in the refectory of Santa Maria delle Grazie and for Raphael’s famous cycle in the Stanze which included the *School of Athens*. Hence the most famous examples of the new spatial experiments in perspective excluded rather than included the general public.

Meanwhile, as the stage in Renaissance Italy became a secular event, it too increasingly excluded individuals except for an inner circle connected with the court. Plays, which had been connected with the power of the gods, now became instruments of the power of ruling men and women. These developments in secular theatre continued the process of interiorization such that the scenes reflected actual places, notably, Ferrara, Venice, Pisa, Florence, Rome and specifically squares that employed a systematic use of space in urban planning, the Piazza San Marco in Venice and the Piazza della Signoria in Florence which, it will be recalled was also the scene that Brunelleschi used for his second perspectival demonstration. Hence the new theatre showed perspectival views of open, public spaces in closed, private spaces. In early cases the stage was limited to one of the four walls. The courtyard of the Pitti marked an important next stage in this process. On special occasions, the open space connecting it with the Boboli gardens outside was closed in, as was the ceiling, such that the entire courtyard became a ludic space (pl. 59-60). Once entirely closed in, the space could be used more dramatically.

Renaissance homes such as the Strozzi palace imitated the structure of Roman villas with a central atrium-like courtyard that functioned as a large window into the sky above. The tradition of ceiling painting that became known as quadratura interiorized this experience by painting views of skylights on closed ceilings. These ranged in size from Mantegna’s Oculus in the *Room of the married couple* (*Camera degli sposi*), in Mantua, to all encompassing ceilings such as that of Pozzo in the church of Saint Ignatius in Rome. Peruzzi’s experiments in the Farnesina applied the same principle to the walls of a room, such that the perspectival paintings gave one a sense of looking out of a room that was in fact fully enclosed. Here again the nexus between interiorization and privatization was apparent. For the more enclosed and controlled the visual aspects of the rooms became, the more they needed to be seen from a specific point of view, which typically entailed that of the owner. In retrospect, these illusionistic rooms can be seen as static prototypes of virtual reality, such that homes became a series of imaginary spaces through which one moved. Very gradually this exclusive process led in the reverse direction. For what began as a game of kings, spread to dukes, then the gentry and ever so slowly towards versions accessible to everyman.

From at least the time of Alberti there had been adaptations of the camera obscura principle to create miniature rooms. The seventeenth century brought new portable versions of the *camera obscura*, as well as developments by Dutch artists to create peep shows (the *perspectifkas*) into perspectival rooms and interiors. The eighteenth century extended this idea to create optical glasses (*optiques* or zograscopes) and show-boxes (*Guckkasten*) the latter sometimes with moving images (pl. 80-84).
The rise of panoramas in the last quarter of the eighteenth century marked a next important chapter. Instead of a community surrounded by nature viewing a small stage, a small group of individuals now stood in a stage-like central area surrounded by a man-made scene which in the early panoramas typically involved the built environment: major cities such as London, Glasgow, Saint Petersburg, and Berlin. Gradually taste expanded to include smaller cities such as Ratisbon, then places outside the cities such as the Scottish peaks, and increasingly to exotic places where one would normally not go as an average person: the Isle of Gibraltar, the Escorial, even Mayan temples until the scenes involved places one preferred to see at a distance as a substitute for having to actually visit them: standing next to the lava flow of a volcano, at sea in the midst of a tumultuous storm or in the midst of a major battle. This process of aestheticization of danger went hand in hand with a German literary movement called storm and force (Sturm und Drang) which saw a new emphasis on individual experience.

The nineteenth century developed these themes on two fronts. One continued the public context where the quest for a moving version of the panorama led eventually to the moving picture and the cinema. Another front incorporated the themes of these public panoramas with the tradition of show-boxes to produce a series of new viewfinder-like instruments with exotic names such as diorama, panoptical optic, panopticon and eudophistikon. Wheatstone’s stereoscope, consciously building on the earlier ideas of Leonardo, marked a next step. Hence by the mid-nineteenth century the process of interiorization and personalization of the external world had been adapted to individual experience: thus providing a visual equivalent of the novel which permitted a person to go on an individual journey by reading.

The twentieth century rendered universally accessible this concept of a viewfinder and added the possibility of viewing simple motion. It also developed new equivalents in the form of portable televisions. The Sony Walkman offered to the ear a personal version of an electronic environment that accompanied one as one moved. More recently the Sony Diskman has begun to offer an equivalent for the eye. Head Mounted Displays will soon integrate the principle of stereoscopic television with stereophonic sound to create a new version of virtual reality. In all these developments the window principle remains important.

3. Correspondence and Non Correspondence

In the early development of perspective the window played an even more central role and applied to exterior as well as interior space. Both in Italy and in the North, proto-perspectival paintings regularly employed a window, which literally opened a view to the outside world. In some cases a door functioned as a window, and in some cases the window which Alberti termed an intersection became literally a section which cut away the exterior wall of a church or a room in order to open up the interior space. Leonardo also called the window a wall (i.e. a transparent wall, pariete, muro). This section or window, served simultaneously to frame the surrounding world and limit the painting to that part encompassed by the lines converging towards a vanishing point. A physical window, as a drawing instrument, became a starting point for Alberti’s perspective because its transparency enabled one literally to record images on its surface, or via a grid to record them onto an adjacent drawing board. Even so it was over a half century
(c.1492) before Leonardo actually drew the window in action; almost a century (1525) before Dürer published it; a century and a half before published accounts of its military applications spread (1595, 1604); and nearly two centuries before its use as a one of the basic instruments for optical and perspectival demonstrations was fully established in the early seventeenth century by authors such as Marolois (1614), and Dubreuil (1642-1649). The work of Accolti (1625), Bosse (1648 etc) and Troili (1672) linked the window with precise quantitative measurement. The eighteenth and nineteenth centuries continued this tradition establishing new interplay with other instruments such as the camera obscura, camera lucida, and show boxes.

From the time of the earliest proto-perspectival examples in the thirteenth through to the impressionists in the nineteenth century, the window was seen as opening a view to the natural world and as an instrument that guaranteed a precise correspondence between this natural world and representations thereof. In our view, it was the perspectival window in particular and geometrical drawing instruments in general that transformed the ancient ideals of mimesis in the sense of subjective imitation, into a Renaissance ideal of matching which claimed a potential one to one correspondence between original in Nature and a record in the form of drawing or painting.

As an instrument that promised mastery of the objective world, the window was seen as a key to objectivity. This ideal led Commandino and his student Guidobaldo del Monte to link perspective with mathematical principles. These links were developed in Paris. Hence the appearance of a perspectival window in the French Academy of Sciences and Fine Arts and later on the title page to Newton’s *Optics*. And hence the assertion by some nineteenth century thinkers that perspective was simply a branch of descriptive geometry entirely independent of optics.

For some artists such as Abraham Bosse, the first professor of perspective in the French Academy of Arts and Science, this goal was so noble that it warranted ignoring and suppressing subjective aspects of vision. Hence his statement that one should draw what is there (the objective geometry of the window), rather than what the eye sees (the subjective angles of apparent size). Many of his colleagues disagreed to the point of expelling him as a teacher of perspective. They wanted perspective to include subjective aspects of the eye and the imagination. The rise of romanticism in the nineteenth century increased this yearning for access to subjective aspects of the imagination. Geometrical drawing instruments became seen as inimical to this aim as did perspective which had fallen increasingly into the domain of drawing academies and was often associated with these mechanical devices. A rhetoric emerged that dismissed perspective as merely or even purely academic and mechanical.

The rise of photography brought these developments into greater focus. In a sense the photographic camera marked the logical conclusion of a fascination linking apertures in the form of a camera obscuras and images that had emerged a thousand years earlier. In the past decades there have been polemical debates as to whether photography had a great impact on new developments in painting or whether it was painting that had a great impact on the new invention of photography. Both were true. At the same time photography provided a physical demonstration that the window principle of perspective was a function of objective geometry independent of the subjective interventions of a
painter and as such it helped artists to recognize that their goals could not be limited to
problems of matching which involved a one to one correspondence between original and
image.

The quest to identify an artistic domain independent of the objective strictures of
perspective led in various directions. The impressionists complemented the study of a
space with a study of time: no longer just a townscape or a landscape, but rather a
specific square in Paris seen on a rainy afternoon in autumn, the banks of a river seen at
lunchtime on a summer’s day or a view of a cornfield in the country in the south of
France on a specific day. Some focussed on the details of the optical experience. Artists
such as Cezanne and Van Gogh, included subjective appearances such that straight lines
were recorded as curves on the canvas. Artists such as Monet, Manet, and Seurat,
emphasized effects of light and colour to the extent that colours competed with forms.
One consequence was awareness of the surface of the painting as surface.

With the Cubists this developed into attention to the surface of the painting as surface.
Hence the rise of collage effects in Picasso, Braque and Leger. Scholars have tended to
interpret this as the end of the window story in particular and of perspective in general.
This is not the case. If we look at one of the classic examples of cubism, Juan Gris’, Still
life with a landscape (Philadelphia, 1915), showing the Place Ravignan in Paris, the
foreground appears at first sight to negate the rules of perspective. We then note that
there is a window in the background that functions in the manner of a Renaissance
window, opening into the space of the street beyond. As we look more carefully we see
that the wall to the left of the window, which would normally occlude what is beyond it
also functions as a window. When we look again at the foreground we recognize a
similar play with occlusion and non-occlusion. A series of different planes partially
occlude, partially transform yet simultaneously reveal the words Le journal. Far from
being isolated examples these new versions of the window principle offer a key to
understanding many aspects of cubism and other branches of modern art which can
effectively be described as experiments with transparency-opacity laws.

**Reversals of the transparency-opacity laws**

The Renaissance version of the window assumed a potential correspondence between
object and image. Its claims for objectivity involved a premise that some objects are
transparent and others are opaque. Transparent objects function as windows and open
into spaces beyond. Opaque objects function as walls and occlude spaces beyond.
Twentieth century art has challenged this premise. The attention to surface as surface by
cubists such as Braque effectively explored the consequences of everything being
opaque, of having no windows into spaces beyond. Artists such as Gris and Leger
explored a much more daring possibility: what if one made the functions of transparency
and opacity interchangeable, such that walls could be windows and windows could be
walls? Surrealism can be seen as systematic reversal of traditional laws of transparency
and opacity in order to explore the potentials of this assumption as a new means of
recovering subjective dimensions of representation. Surrealism combined this with a
deliberate play of viewpoints to spark the imagination.

Romantic painters such as Caspar David Friedrich had drawn figures literally looking out
of windows from a viewpoint just behind the figure, such that we as observers were cast
into the position of looking at the person looking, able to imagine what they saw, yet distinct from their viewpoint. Dali painted a *Girl standing at a window* (1925) in a similar position. Magritte went one step further by painting the figure who is looking out as herself being outside the room. In addition he painted the outside of the window rather than the inside. Our first assumption that we are inside a room looking outside at a landscape is completely contradicted. So it is as if we were inside looking at a landscape seen by a woman who is outside framed by a window as if it were who was outside looking in. This same principle without a human figure is employed in the *Revolution* (London, Private Collection), and in his *Praise of dialectic* (*Eloge de la dialectique*, Robert Giron Collection, 1937). In these paintings a single seemingly coherent space integrates a series of viewpoints and thus launches us directly into games of the imagination.

The window is a leitmotif in Magritte’s paintings. It dominates his *Human condition* (*La condition humaine*, Paris, Claus Spaak Collection, 1934, pl. 119.2), in which a canvas is flush with the window. Theoretically a canvas is opaque and should occlude what is beyond it. Magritte’s canvas simultaneously suggests a transparent window and shows an opaque canvas that it makes possible. Magritte was very articulate about his purpose:

> The problem of the window gave rise to *The human condition*. In front of a window seen from inside a room, I placed a painting representing exactly that portion of the landscape covered by the painting. Thus the tree in the picture hid the tree behind it, outside the room. For the spectator, it was both inside the room within the painting and outside in the real landscape. [This is how we see the world.] We see it outside ourselves, and at the same time we only have a representation of it in ourselves. In the same way, we sometimes situate in the past that which is happening in the present, as occurs in cases of false recognition. [Time and space thus lose the vulgar meaning that only daily experience takes into account.]

Magritte’s *Promenades of Euclid* (New York, A. Iolas Gallery, 1955), takes this play of opacity and transparency one step further. Now we are looking frontally at the canvas and it would in theory occlude entirely the view beyond. This is attention to the surface as surface with a new twist. Moreover, beyond the window-canvas we see a street and a tower which can simultaneously be seen as two versions of the visual pyramid and hence as lessons in other ambiguities between two- and three-dimensional objects. Related themes can be found in other paintings where windows at once transparent and opaque dominate: e.g. his *Domain of Arnheim* (New York, Private collection, 1949), or his *Nightfall* (Private collection, 1964). Sometimes the canvas which we by now expect to be transparent depics the scene beyond it in another scale as in his two versions of the *Waterfall* (*La cascade*, New York, Collection Harry Torczyner and Gstaad, Private collection, 1961), showing trees at a distance where we expect leaves. Sometimes the outlines of plants, which should theoretically occlude what is beyond function as windows as in *Plagiarism* (*Le plagiat*, New York, Private collection, 1960), and the *Land of marvels* (*Le pays des miracles*, Brussels, Private collection, 1960).

Another series of paintings involve doors that function as windows. One of the earliest of these was the *Unexpected answer* (*La réponse imprèvue*, Brussels, Musées royaux des
beaux arts, 1936, pl. 119.3). This showed a closed door which would ordinarily occlude what was beyond it, opened by a figure-like aperture which allowed one to see the occluding darkness of the space that it opened. This concept was pursued in his *Amorous perspective* (*La perspective amoureuse*, Brussels, Private collection, 1935, pl. 119.4), where a similar opening in a closed door reveals an opening with a view that is occluded by a leaf in the form of a leafless tree. In one of his most famous paintings, *Personal values* (*Les valeurs personelles*, New York, private collection, 1952, pl. 120.1-2), this reversal of transparency-opacity is applied to a room in which the normally opaque walls function as windows into clouds, whereas the mirror reflects a non-existent window. These effects are heightened by the presence of five objects of everyday life, a glass, comb, soap, shaving brush and match positioned in a larger than life scale. The comb which we expect to be opaque is transparent. The glass which we expect to be transparent is effectively opaque.

Magritte is often remembered for his image of a pipe with a caption, *This is not a pipe* (*Ceci n’est pas une pipe*, New York, Collection William N. Copley, 1929). That same year he wrote an essay on *Words and images* (*Les mots et les images*) in the *Surrealist revolution* (*La révolution surréaliste*), where he discussed various ways in which words and images can interact, for instance how a word can substitute an image, or use an image to represent a word other than itself. He returned to these ideas in his *Notes for an illustrated lecture at the London Gallery* (February 1937). He cited the familiar image of a bird in a cage and considered the possibility of replacing the bird with a fish or a shoe. He noted that while curious, such images were unfortunately arbitrary and accidental, adding:

> It is however possible to obtain a new image which will provide greater resistance to the spectator’s examination. A large egg in the cage appears to be the necessary solution.

Let us now occupy ourselves with the door. The door can open up into a landscape seen in reverse. The landscape can be represented on the door.

Let us try something less arbitrary. Beside the door let us make a hole in the wall which is also another door. This encounter will be perfected if we reduce the two objects to a single one. Thus the hole places itself naturally in the door and through this hole one sees obscurity.

This image could be further enriched if one cast light on the invisible object hidden by the obscurity. Our gaze always wants to go further, wants in the end to see the object, the reason for our existence.559

This passage is of the greatest interest because it reveals that while surrealists such as Magritte were explicitly concerned with challenging the ideal of a one to one correspondence between object and image introduced by Renaissance perspective, they recognized that a completely arbitrary play with these principles would result in images that were meaningless. Playing with the assumptions of transparency and opacity, while maintaining the geometrical framework of perspectival space was Magritte’s personal solution.

Many of Paul Delvaux’s paintings are closely related. He too has enclosing spaces such as church interiors and temples which should in theory occlude the space beyond but in
fact open it, some walls which are literally windows, some walls which function as windows, others which are open spaces although we expect them to be closed. Some of his paintings use buildings and roads to create views converging towards a vanishing point in the far distance. Other paintings use buildings and roads to concentrate the space in the foreground of the picture. Other paintings are more complex. What appears at first sight to be a scene using traditional linear perspective reveals itself to have increasingly curved lines off to the side as in his *Dryads* (*Les Dryades*, Private Collection, 1966). In still other cases he deliberately combines a series of different vanishing points in a manner reminiscent of De Chirico’s method of polyvalent perspective.

Salvador Dali is not often associated with Magritte and yet in terms of this playful method which reverses traditional transparency-opacity laws, there are remarkable parallels. Magritte used doors that both occluded and gave a view of what was beyond. Dali explored this in his *Skull of Zurbaran*. Magritte explored ambiguities of walls that functioned as windows. So too did Dali in his *Animated still life* and implicitly in his *Sacrament of the Last Supper* where the traditional room is encompassed by an open dodecahedron that offers a panoramic view of a lake and hills beyond. He adapted this idea brilliantly in his *Suburbs of the paranoiac-critical town* where the image of a keyhole and its surrounding lock in the foreground on the right is repeated in the background to become a figure in an open gateway. On the left side of the picture this combination recurs in a subtler form.

Magritte played with the idea of a human form functioning as a window in his *Decalomania* (Brussels, Collection Mme. Chaim Pelreman, 1966) and a human head as a window in his *Painted plaster cast from Napoleon’s death mask* (Chichester, Collection Edward James, c. 1935). These became important themes for Dali, sometimes very obviously as in his *Couple with their heads full of clouds*, his *Birth of a goddess* or *Old age, adolescence and infancy*, sometimes less so as in his *Portrait of Gala in circles*, and on other occasions very subtly indeed as in his *Portrait of Abraham Lincoln* which, from a certain distance functions as an opaque object and from another distance resolves itself into a cross-like window from which Gala is looking out into the distance. Even more complex is a portrait of Voltaire that recurs in the background of both his *Slave market with disappearing bust of Voltaire* and *Resurrection of the flesh*. Seen from one distance it is a portrait: seen from another it dissolves into three figures framed by an open portal. His *Great paranoiac* and *Apotheosis of the dollar* contain variants on this theme. In his *Illumined pleasures* two of the framed images have more depth than the rest of the painting and a third canvas is actually a painted box that functions as a window.

Seen in this context there is much more to Dali’s use of perspective than obvious examples such as his *Font* (1936), *Sentimental colloquy* (1944), *Persistence of memory* (1948) or *Christ of Saint John of the cross* (1951). Indeed like Magritte and Delvaux, Dali is playing with the transparency-opacity rules of perspective to create new landscapes of inner worlds of dreams and imagination.

**Windows as walls**
During the Renaissance theorists such as Leonardo had referred to the window alternatively as a window (finestra, pariete) and a wall (muro), intending however in each case a transparent surface which allowed one to depict the world beyond it. As we have noted the Cubists viewed the traditional window as an occluding wall and as a result focussed on the surface of the painting as a surface. More recently, some would claim in direct lineage with the aims of cubism, Hockney has taken up this theme anew, arguing that the perspectival window functions as a wall separating the viewer from the objects represented. He has argued that inverted perspective offers a solution to this dilemma in that when an object is drawn in this fashion, the viewer becomes the vanishing point and in looking at the painting they are drawn into the space of the picture rather than separated from it.

One of Hockney’s most famous paintings in this context is his *Visit with Christopher and Dan, Santa Monica Canyon* (1984). At a first glance we see merely a series of patches of colour. Then we realize we are in a home. On the right side of the canvas Christopher Isherwood is writing. On the left side of the canvas his friend Don Bachardy is painting. In the upper left hand corner we see a house perched on a cliff overlooking the Pacific. Lower down towards the centre of the painting this scene is repeated twice. In front of Don Bachardy the scene is repeated two more times. Thus we have a sensation of looking at a same scene through various windows in the house. To increase the paradox of this effect Hockney depicted a painted version of the same scene above Isherwood’s writing desk.

There are dramatic ways in which these themes of windows as occlusions are expressed in contemporary culture. Paris, which in the seventeenth century created its squares, gardens and avenues for their vistas, has now begun to destroy systematically those vistas. In the gardens of the royal palace there are now series of truncated columns, irregularly placed, which interrupt the original view of regularity. More striking is the pyramid at the Louvre which is so placed that one can no longer stand within the walls of the palace and look out through the Tuileries towards the Arch of Triumph. Indeed several new buildings have been built which block that view. Here is a case where former windows into landscapes have been walled up.

**Inner-Outer**

The early practitioners of proto-perspective and linear perspective explored the uses of these new techniques in the context of both exteriors and interiors. The development of these new genres typically went hand in hand, such that perspectival views of rooms contained windows, which revealed exterior views. Only gradually did these new genres emerge as independent forms of expression such that landscapes and interiors were treated separately. Hence the window became a window in a room and then a window in an interior, which gave a view of an exterior in the form of a landscape.

Modern perspective continues these themes but is also transforming the nature of inside-outside, inner and outer. Video shows interiors and exteriors in ways that remove the distinctions between them (pl. 129). Two-dimensional virtual reality as developed by Myron Krueger increases this ambiguity. Some modern paintings based on photography continue distinctions between inner and outer. Others blur these distinctions as in the case of a painting by Robert Gonsalves (Toronto) showing book shelves from an interior
outside on a lawn. A young student from Panama studying in Florida, Earl Lam, has painted a puzzle such that the man depicted in the puzzle is constructing the puzzle from the outside (pl. 121.1). Lam acknowledges the influence of Escher: “He makes you see things that aren’t there, which is what I’m trying to do”\textsuperscript{560}. An English artist, Jim Gaines, photographed a house, which was then cut up in puzzle-form and re-photographed as a Crooked House (pl. 121.2), such that what is in and out is difficult to discern. A painting by Gonsalves pursues these themes. We are shown a painting of a puzzle in which a boy inside a house making a puzzle of a boy outside a house (pl. 122.1-2).

Some examples of spherical perspective take even further these ambiguities of inner and outer. For instance, Dick Termes, has a painting entitled God’s Eye View (pl. 136.1), showing the interior of San Spirito (Florence) by Brunelleschi, (said to have been the first church constructed with a view to co-ordinating perspectival effects into architecture). Termes depicts this interior on the exterior of a sphere. In the case of Order in Disorder, this interplay of interior-exterior is rendered the more extreme when we recognize that the artist painted these exteriors from inside the sphere. In Termes’ Pieces of the Whole, we have a viewpoint from the outside showing boys painting the scenes in which they are painting.

The introduction of various alternative mapping techniques has increased these paradoxical treatments of inner and outer. Cartographers have explored new ways of morphing planes such that satellite images can be “draped” over contour maps to transform two-dimensional photographs into three-dimensional spatial images. For instance, Brandenberger\textsuperscript{561} shows how a map of the University of Zurich (pl. 88) can be warped to fit different curved planes. It is intriguing to note that artists such as Escher have been pursuing analogous experiments in spatial transformation\textsuperscript{562}.

One of his most complex examples of these impossible windows began with his three colour woodcut of a ship in the foreground with a view of the city of in the background entitled Senglea (1935, pl. 123.3). In a subsequent lithograph entitled Balcony (1945, pl. 123.1) showing a closer view of the buildings of the same town, he transformed the rectilinear plane to a spherical one. Escher pursued this theme in his Studies for a print exhibition (1956, pl. 124.2) where he began with a slightly distorted corridor containing various prints. In a second study, the size of one of the represented prints was greatly expanded, distorted and made transparent to function as a window again revealing the ship in the harbour and town in the “background”, which at the same time dominates the upper half of the picture. In the foreground is a grid pattern of windows. As a result Escher achieved an effect whereby we as viewers are outside the space looking into the hall of prints and yet at the same time inside the hall looking out at the town beyond the walls (pl. 124.2).

By consciously inverting the regular laws of transparency and occlusion, a conscious play with interior and exterior space is created. Inner and outer are fully ambiguous. More importantly for our theme, the transformations and alterations of images which we now associate with electronic tools were introduced by artists. The difference, of course, is that artists’ transformations required a great deal of effort and had built into them a personal signature, whereas their electronic equivalents require hardly any effort and lack
a personal signature. For this reason it makes sense to distinguish a spectrum of possibilities ranging from direct correspondence to non-correspondence.

Renaissance perspective assumed a one-to-one correspondence between each point on an original object and an image. Modern perspective sometimes entails a one-to-one correspondence, but the nature thereof varies greatly: sometimes it is theoretical, assumed, possible, transposed or deliberately not a direct correspondence. These new kinds of correspondence have greatly expanded the scope of perspective.

Theoretical Correspondence

Technically speaking a one-to-one correspondence is only possible in the case of vector graphics, where entire lines are copied. In the case of raster graphics the copying of points presents problems of aliasing especially in the case of distant objects. As we have shown earlier (see above p. 142*), the underlying assumptions governing perspective apply equally to pixel projection used in ray tracing. Indeed we found that Lansdale, in a fundamental dissertation on the subject, demonstrated lucidly how the principles of linear perspective can be extended to discrete pixels in ray tracing and radiosity programs; that while in traditional Renaissance perspective one often began with a square tile parallel or at right angles to the picture plane and recorded its projected size, in Lansdale’s approach this procedure is reversed: i.e. a square pixel is treated in the manner of a projected square tile on the picture plane or screen and is then projected back onto the textured 3-D object (fig. 33-36): i.e. precisely the reverse of an anamorphic form which is projected as a regular sphere on a tilted projection plane. Hence we claimed that perspective remains a valuable tool in understanding the frontiers of aliasing problems in image processing.

Fractals pose one of the most complex examples with respect to theoretical correspondence between original and image. According to Mandelbrot (1977*), the rectilinear properties of Euclidean geometry imposed serious restrictions on attempts to analyze the curvilinear complexities of (organic and inorganic) Nature. As an example, he gave the coast of England, pointing out that if one chose smaller measuring sticks the number of sides and length of the coastline would increase greatly. Perspective had assumed that only size changed with distance or scale. In Mandelbrot’s example, shape was also a function of scale or distance. He proposed that fractals offered a way of getting beyond these restrictions. Unfortunately because fractals involve iterations, changes in scale affect only their size but not their shape. Hence, strictly speaking, discussions concerning fractals have brought into focus a important problem which fractals are not able to solve.

Needed is a new approach to perspective which defines the scales within which the traditional laws of size as a function of distance are maintained, and identifies those changes of scale where both shape and size become a function of distance. Interestingly enough this is a case where we have been familiar with the underlying problem for centuries in a quite different context. Anyone who has used a microscope knows perfectly well that increasing the scale changes the shape as well as the size of the insect or specimen which we examining and yet within a certain range of scales shape remains effectively constant while size changes. It is this phenomenon to which fractals have drawn attention and which a future scaled approach to perspective will need to solve.
The limitations of present day fractals have not prevented enthusiasts such as Barnsley\textsuperscript{567} from claiming that fractals can in fact reproduce Nature efficiently. Paradoxically as compression ratios increase fractal landscapes look increasingly plausible as illustrated by software programs such as VistaPro (pl. 141-142). When combined with ancillary programmes one can create impressive perspectival fly-bys. As a result, fractals, which seem to contradict the principles of perspective have become a new source of perspectival experiences.

**Assumed Correspondence**

In Europe there has been tendency to use experience of present objects to visualize past objects. Among the most striking examples to date are IBM’s elaborate reconstruction of the former Abbey at Cluny\textsuperscript{568} (pl. 109) and of the Frauenkirche in Dresden which was bombed in the second World War, or the excellent work done by Iwainsky in reconstructing the great Pergamon altar. Also impressive is the reconstruction to scale by Chimenti and Menci (Arezzo) of 11,000 houses and buildings in Florence at the time of Lorenzo the Magnificent.

In these cases there is an assumed correspondence between image and the original object, which is sometimes no longer extant. This applies equally to persons and animals. For example, in the case of *Terminator II* (1991), the animated robot is so impressive largely because it is a perfect clone of a real figure. Similarly the animated dinosaurs in *Jurassic Park* (1993), are assumed to correspond to how they actually looked in real life according to the latest theories.

**Possible Correspondence**

In the United States, the exploration of possible correspondence is much more marked than elsewhere. Indeed it has been the subject of a new field called scientific visualization, championed by centres such as the National Center for Supercomputing Applications (NCSA) at Urbana-Champaign, Illinois. This entails a whole range of applications including dynamic simulations of chemical bonding, visualizations of shock patterns and models of complex weather phenomena such as smog and violent storms. Much of this visualization is concerned with the frontiers of quantitative science and frequently requires the use of Cray computers. At the same time there are other contexts whereby such possible correspondence serves as a starting point in very different directions as in the following quote:

> Image Capture is where the image actually begins its trip into reality. If you can call it reality. Often our ideas are conceived with reality as the basis, but they depend on our audience’s ability to suspend disbelief and play along with you as toy with their perception of what is real and what is fantastic. The fun comes when we can make a seamless transition into a world we know is not real but into which we gladly enter\textsuperscript{569}.

What makes this striking is not so much the statement itself as its context, namely, the introduction to a recent booklet by Kodak. There is of course considerable interest in realism in the United States: witness the amount of attention paid to news. Yet, increasingly the approach to news as a documentary of what actually happened is being undermined by a notion of news as a combination of real and imaginary. Information is
combined with entertainment to pose as info-tainment; education is combined with
entertainment to pose as edu-tainment such that the event in itself is considered somehow
to be suspect because it lacks the (enter-) tainment side of things. Individuals watch the
CNN version of the Iraq war, conscious that they are witnessing a staged event reported
from one side, and yet there is no framework for making visible other versions of the
reality.

In the United States, there has also been a deliberate strategy of using experience of real
places and things to visualize unexperienced ones. For instance, members of NASA study
rocky places in Nevada and California deserts in preparing for explorations on the moon,
Mars and other planets. While this has obvious pragmatic advantages, it introduces a
danger philosophically that persons lose their sense of difference and the other. Is the
American tourist abroad who is continually saying that there is something bigger, better
or very similar back home in the United States merely a stereotype or actually a direct
consequence of this mentality? Klotz has recently suggested that this marks a rejection
of Renaissance perspective, which deserves further analysis:

Simulation is a further step away from the vanishing point of Renaissance
perspective towards a world of appearances which is virtually real for the subject.
A person can get so wrapped up in this apparent world, as if they could live in it,
as if they themselves as a three-dimensional being existed in an artistically
produced three-dimensional space. This is a new theme that one should study.

On the positive side, there have been a number of famous applications of this principle in
the case of the cinema. For instance, Steven Spielberg has explored this in films such as
E.T. (1982) and Gremlins (1984, 1990). Equally, if not more famous, is George Lucas,
whose special effects facility, Industrial Light and Magic (ILM) has produced movies
such as Star Wars (1977), Raiders of the Lost Ark (1981), Willow (1988), and worked

**Transposed Correspondence**

Sometimes one may deliberately choose to have no direct correspondence between
original and image and yet use an external visible experience as a metaphor for some
otherwise invisible experience. For example, some investment firms have begun using
images of grain fields as a metaphor for fluctuations in the stock market. Is this
insistence on visualizing situations of transposed correspondence (where no direct
 correspondence is possible) one of the reasons why metaphors have become such a
buzzword in the United States and why they are treated with such unexpected
seriousness? To a European, *Metaphors we live by*, could readily sound more like a
parody than the title of a scholarly tome.

It should be noted that some individuals take this metaphorical treatment seriously. A
Toronto based firm, Visible Decisions, has copyrighted the term “information animation”
and sees in these new techniques a new methodology for understanding statistics in a
space-time continuum. Interestingly enough a Singapore scholar working in the realm of
knowledge navigation has reached similar conclusions independently.

**No Direct Correspondence**
Sometimes there is no direct correspondence at all as in cases when the external world is used as as a point of departure for images of the internal world. In the case of films such as *Fantastic Voyage* (1966), this reconstruction can be remarkably realistic. In others such as *Tron* (1982), the spaces are much more idealized.

Theoretically photography promised a one to one correspondence between original and image and as we have noted (above p. 118*) this principle has proven of great interest to architects such as Jantzen who have applied it to situations, which combined a photographic record of an existing situation with an architect’s conception of possible modifications to this same space. As Gombrich (1975, 1976, 1980), has shown however a one to one correspondence between object and image is by no means necessary. Even when the link between object and photographic image is precise, the artist may nonetheless choose to create a non-correspondence between photographic exemplar and painted result. By way of illustration the work of three artists will be cited.

The first is a Toronto artist, Robert Gonsalves, mentioned earlier (p. 223), who deserves to be much better known. One of his works is based on a simple photograph showing the interior of Saint Basil’s Church at Saint Michael’s College, in the University of Toronto. His “non-corresponding” painting uses the walls of the original church as a point of departure, with the difference that at a certain point the columns are transformed into trunks of trees and the intertwining arches of the vault are metamorphosed into an arboreal play of knots reminiscent of the Sala delle Asse in Milan. A second photograph, shows a nineteenth century view of Saint Michael’s cathedral along with Metropolitan United Church. The resulting painting adopts the original disposition of the buildings, reverses this with respect to the photograph and then transforms the conventional architecture into Gaudi-esque towers, which have anthropomorphized praying hands. As a result both paintings while consciously using photographs as their starting points result in images which are deliberate statements of non-correspondence.

In the case of David Hockney these transformations are more difficult to follow but the end result is analogous. Indeed, at first sight, his *Portrait of Mr. and Mrs. Clark and Percy* (pl. 131.3), looks perfectly photographic, as if there were a simple correspondence between what he photographed and what he subsequently painted. In fact, as Webb (1988), has shown, the situation is considerably more complex. Having made a photograph of the whole, Hockney made individual drawings of the man as a whole (pl. 131.1-2), drew a detail of his bust (pl. 131.4) and then synthesized these elements in his final portrait. In the case of Hockney’s portrait of his friend Gregory, the situation between original figures, photographs and final painting is more subtle. The representation of Hockney himself is essentially a self-portrait. By contrast, the representation of Gregory is based on a whole series of photographs. In the final painting of a *Model with unfinished self-portrait* (1977), this series has been reduced to a single image as if there were a one-to-one correspondence, but is then integrated with the self-portrait using a different spatial technique, thus simultaneously contrasting the spaces of the two portraits. In the case of the portrait of his friend Peter Schlesinger, this process is even more complex. The stance of his friend is based on a photograph taken in Kew Gardens in London, England. The figure swimming in the pool is based on a series of photographs taken in a pool in California. These diverse elements from two continents
were then merged to produce a *Portrait of an artist* (1972), that looks as if it corresponded to a single space and time but deliberately does not.

On other occasions Hockney uses photography in ways which draw attention to the absence of a one to one correspondence between object and image as when he joins together a whole series of photographs in order to arrive at a single composite picture of an object such as the *Brooklyn Bridge*, a scene such as his *Luncheon at the Japanese embassy*, or a panoramic view such as that of the *Grand canyon*, his *Terrace with shadows* (pl. 132.1), or his *Pearblossom highway* (1986, pl. 132.2). In these examples his concern is to capture aspects of time as well as space. Hockney also uses photography to demonstrate his theory of inverted perspective as a means of integrating subject and object and of integrating effects of time and motion within his painting.

In the case of Dick Termes, interests in photography have complemented and reinforced his fascination with poly-perspectival methods using a number of surfaces. His patent of 1981 (fig. 19), involved using a camera to take twelve co-ordinated views from a single centre, which images could then be mounted on the sides of a dodecahedron (pl. 133-134). Since then he has developed variants using other regular solids

4. Alternative Planes

The perspectival window as used by Brunelleschi and Alberti was flat. Already during the Renaissance (cf. above p. 119-126*), convex mirrors and irregular shaped walls prompted artists to explore alternative windows. Nineteenth century romanticism brought with it a new emphasis on subjective sensations. Rectilinear windows were increasingly associated with the objective regularities of descriptive geometry and artists. Meanwhile, as we have noted, the optical studies of scientists such as Volkmann, Hering, and Helmholtz, claimed that visual space was not rectilinear, and might correspond instead to the space of non-Euclidean geometries being developed by Bolyai, Lobatchevsky, Riemann, and others. Hence these same scientists argued that a simple one-to-one correspondence between retinal image and visual image was impossible: i.e. that the analogy between camera obscura and eye was false, or to use modern terms, that the analogue theory had to be replaced by a digital theory of images. Ironically, artists have ignored these findings and focussed increasingly on spherical surfaces in an attempt to record what would traditionally have been termed subjective aspects of optical experience, but to which they often refer as objective aspects.

Since we have already described (above pp. 119-126*) the major theories and practices that have resulted, a summary outline will suffice at this point. Some artists attempt to reproduce the concave surface of the retina (Stark). Others focus on reproducing the convex shape of the eyeball (Barre and Flocon), recording their results on a rectilinear plane. In so doing they are faced with problems of translating images from a spherical to a flat surface in ways similar to those of cartographers as some artists have themselves noted (Barre and Flocon). Studies of spherical map projections by Tobler (1964), have used transformations of a human face to demonstrate the anamorphic effects involved. As a result cartographic projections offer a range of new windows. Other artists use non-linear surfaces both for production and demonstration of their images. Some use large cylindrical surfaces (Day). Some use actual spherical and even polyhedral surfaces
(Termes). As a result the traditional rectilinear window now competes with a whole range of alternative windows.

The range of these alternatives has been further increased by the domain of psychological optics where, as we have noted (above p. 184*) the studies of Hering, Wundt, and their successors brought into focus many ambiguities of vision arising from geometrical illusions. One of these, which relates closely to the figure-ground discussions of the Gestalt school, is the Necker cube. This series of simple lines in parallel perspective can easily be read in two different ways such that when one stares at the figure the alternative readings oscillate from one reading to the other. If these simple lines are replaced by solid ones, a more complex phenomenon emerges. One of the readings involves an impossible cube which we can see as a representation but for which we cannot construct a physical object. This reading becomes the more convincing in the case of a three-dimensional version of a Necker cube where non-correspondence between image and object becomes a question of necessity rather than choice, thus implicitly bringing into play ambiguous and impossible windows, where the image looks fully realistic yet cannot correspond to actual objects. Escher drew a seated man holding such an impossible cube. This became a starting point for his lithograph of a Belvedere (19**), where the man and cube were positioned beside a two storey loggia, which repeated the phenomenon with columns such that these appeared to interlace in an impossible way. Escher developed a whole series of variations on this theme and indeed the deliberate juxtaposition of spaces involved has become one of the central aspects of his work.

Closely related to the Necker cube is an impossible triangle which Reutersvaard (1934), originally designed using nine cubes. Penrose and Penrose (1958), in a now famous article, studied the implications of this shape which has subsequently become known as a Penrose triangle and which recurs in one of Termes’ spheres.

5. Anti-ocularism

It is important to note that there is a growing school that offers a very different interpretation to the history of vision in general and perspective in particular, whereby vision is treated as something very negative, an attitude that reflects itself in a number of recent titles (fig. 70). Discussions by traditional scholars such as Stafford (1993, 265), of “antivisual rhetoric” gives some indication of the significance of this school.

Some progress towards a global view of these problems was provided by Levin (1988), The opening of vision: nihilism and the postmodern situation and Levin (1993), Modernity and the hegemony of vision. The best synopsis thus far has been offered by Martin Jay (1993), Downcast eyes. The denigration of vision in twentieth century French thought, the chapter themes and individuals of which give a masterful survey of the situation (fig. 71). Jay also outlined a number of concepts with which vision has been associated (fig. 72).

<table>
<thead>
<tr>
<th>Author</th>
<th>Title</th>
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<tbody>
<tr>
<td>Eager (1961)</td>
<td>“The missing and mutilated eye in contemporary art”</td>
</tr>
<tr>
<td>Clark (1981)</td>
<td>“Iconophobia”</td>
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De Certeau (1983)  “Madness of vision”
Rassial (1985)  The interdiction on representation
Krauss (1986)  “Antivision”
Buci-Glucksmann (1986)  Folly of vision
Juddovitz (1986)  “Anemic vision in Duchamp”
Stich (1990)  Anxious visions: Surrealist art
Sitney (1990)  Modernist montage: obscurity of vision in cinema and literature
Krauss (1993)  Optical unconscious

Fig. 83. A series of recent titles reflecting the anti-visual approach.

Author    Trend
Impressionists to Bergson  Crisis of ancient scopic regime
Sartre, Merleau-Ponty  Search for new ontology of sight
Lacan, Althusser  Specular subject of ideology
Foucault, Debor d  From the empire of the gaze to the society of the spectacle
Barthes, Metz,  Cahiers du cinema, Camera as memento mori
Derrida, Irigaray  Phallogocularcentrism
Levinas, Lyotard  Ethics of blindness and the postmodern sublime

Fig. 84. Individuals and chapter themes reflecting an anti-visual approach in Jay (1993).

Author    Associated Concepts
Gibson  Privilege synchronic stasis
Descartes  Active potential ...probing, penetrating, searching qualities
Said (1979)  Power...in sustaining imperialist and racist domination
Freud (1962)  Sexuality, mastery
Lacan (1928ff.)  Aggression
Copjec (1989)  Ambiguous, treacherous, full of traps
Althusser  Ideology
Miller (1975)  Surveillance...potent mechanism for social control
Situationists  Lust
Barthes  Death, thanatology
Irigaray  Phallic, phallocentrism

Fig. 85. Adjectives linked with the eye, vision or gaze in contemporary French criticism according to Jay (1993).\textsuperscript{576}
Jay offered a highly articulate interpretation (577) of the history of perspective. He claimed, for instance that the “dennarativization” was helped by perspective, not mentioning the evidence that perspective also expanded the horizons of narrative (cf. above pp. 21-25,153). Citing the work of Berger and Bryson, Jay (55) claimed that, as a result of perspective, “both painter and viewer were bracketed, at least tendentially, in favor of an eternalized eye above temporal duration”. He also paraphrased Alpers’ more dramatic formulation of this claim (56): “The reduction of vision to the Medusan gaze (or often the male gaze contemplating the female nude) and the loss of its potential for movement in the temporal glance was now ratified, at least according to the logic, - if not always the actual practice - of perspectival art.”

From Alpers, Jay also adopted an imaginative opposition between Italian and Northern art (fig. 73) which, as Veltman (198*), noted in a review, unfortunately had little to do with the historical evidence. It did not explain, for example, why Descartes who was French, lived in Amsterdam and died in Stockholm should be associated with a [Southern] Italian view rather than a Northern one.

<table>
<thead>
<tr>
<th>Italian art</th>
<th>Northern art</th>
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<tbody>
<tr>
<td>Perspectival art</td>
<td>Nonperspectival</td>
</tr>
<tr>
<td>Geometricalized optics</td>
<td>Natural optics</td>
</tr>
<tr>
<td>Conceptualized</td>
<td>Art of describing</td>
</tr>
<tr>
<td>Alberti, Descartes</td>
<td>Kepler</td>
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<tr>
<td>Camera obscura</td>
<td>Camera</td>
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<td>Camera obscura</td>
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<td>Photographs</td>
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Fig. 86. Basic distinctions between Italian and Northern art according to Alpers (1983).

Jay brought into focus a number of unconventional interpretations, citing (55), for instance, Masheck (1991), as challenging the role of the window in Renaissance perspective. He (58) cited Rotman (1987) concerning an analogy linking vanishing point and the concept of zero and referred to Goldstein’s (1988) Marxist theories see above pp. 12-15). In the case of Descartes, he quoted (76) a significant passage in the Optics: “here are no images that must resemble in every respect the objects they represent....Following the rules of perspective, circles are often better represented by ovals than by other circles and squares by diamonds rather than by other squares.”

Passages such as this led Jay (70), to claim that “By moving from resemblances to representations, it can be argued, Descartes was subtly opening the door to a non-visual, linguistically oriented epistemology of judgments.” Following the view of Fried (1980), Jay (102-103), claimed that Diderot also challenged the perspectivalist scenographic tradition: “The primary function of the tableau as Diderot conceived it was not to address or exploit the visibility of the theatrical audience so much as to neutralize that visibility, to wall it off from the action taking place on stage, to put it out of mind for the dramatis personae and the audience alike.”

Jay (134), accepted Berger’s (1972), claim that the advent of the camera changed what had been the perspectival mode of seeing: “What you saw depended upon where you were when. What you saw was relative to your position in time and space. It was no longer possible to imagine everything converging on the human eye as on the vanishing point of
infinity.” He also accepted (159) a claim of Merleau Ponty that: “what recent psychologists have come to formulate: the lived perspective, that which we actually perceive, is not a geometric or photographic one”, blithely overlooking that these debates had a much more complex history (see above pp. 87-107*). He (159), also followed Merleau Ponty’s interpretation of Cézanne, to claim that:

Cézanne wanted to overcome the very distance between viewer and viewed, thus shattering the window’s glass separating beholder form the scene on the other side. His task, therefore, was the recapturing of the very moment when the world was new, before it was fractured into dualisms of subject and object or the modalities of the separate senses.

To this Jay (166), added the view of Shapiro (1982): “Cézanne reduced the intensity of perspective, blunting the convergence of parallel lines in depth, setting the solid objects back from the picture plane and bringing distant objects nearer, to create an effect of contemplativeness in which desire has been suspended”. And whereas as Merleau Ponty had gone on to defend Cézanne, Jay (326) followed Lyotard in insisting on the limitations even of Cézanne’s experiments with curvilinear perspective:

We have no reason to believe that the curvature of Cezannian space, its intrinsic disequilibrium, the passion that the painter experienced for the baroque organization of space ... is any more exempt [than that of other painters] from the marks of desire and better able to restore us to the phenomenality of the sensible.

With respect to Duchamp, Jay noted (167), that the two sections of Duchamp’s Large Glass “the upper that of the ‘bride’, the lower that of the ‘bachelors’, were rendered through two incommensurable spatial projections that defy visual unity. So too does the disparity between the perspectivalist or anamorphic lines etched on the glass and the real world visible through the work’s transparent canvas.” At this point, Jay’s logic became rather questionable. On the one hand he insisted that both perspective and anamorphosis were part of a narrow visual approach that was being overthrown in favour of a new verbal, literary approach. On the other hand, he went on to ask (172): “ What is the role of specular, concave, or anamorphic mirroring in literary texts especially after the mise en abyme became a self-conscious staple of modernist reflexivity?” and then claimed (179) that the “word” effectively functioned as an “anamorphic glass”, such that anamorphosis became a positive alternative to the negative connotations of perspective.

In Jay’s own history of perspective Marcel Duchamp was important because of connections he assumed between art and philosophy. Jay (190), accepted Lyotard’s claim that “Duchamp’s transformations of incommensurability spatial projections with Nietzsche’s destruction of a master point of view”. He believed that there were further connections with literature and hence claimed that (170): “If the history of modernist painting, broadly construed, can be understood as a laboratory of postperspectivalist optical experimentation, with a subcurrent of outright antiretinalism culminating in Duchamp, roughly parallel developments can be discerned in the literary experiments of the French avant-garde”. He went further to insist (188) that there were “ironies” concerning the: “coincidence at the end of the nineteenth century of the dissolution of the perspectival grid in painting and the authorial or narrative point of view in literature, on the one hand and the emergence of aself-conscious ‘perspectivism’ in the other.”
This claim would be fascinating if it were true. As we have seen (above pp. 152-164), however, the evidence points to a rather different story, namely, that Percy Lubbock’s *Craft of Fiction* (1921), which codified the emerging interest in authorial viewpoints was published in the years immediately after Duchamp’s painting and marked a beginning rather than the end of serious examples and studies using this approach.

In Jay’s mind the perspectival approaches of both Descartes and Alberti inherently precluded an individual point of view (189):

> Descartes assumed that the clear and distinct ideas available to anyone’s mental gaze would be exactly the same because of the divinely insured congruence between such ideas and the world of extended matter. Individual perspectives did not, therefore, matter, as the deictic specificity of the subject could be bracketed out in any cognitive endeavour. The same assumption informed the Albertian concept of painterly perspective; all beholders would see the same grid of orthogonal lines converging on the same vanishing point, if they gazed through, as it were, the same camera obscura. Perspective in this sense was atemporal, decorporealized, and transcendental.

In an earlier discussion (cf. fig. 73) Jay had accepted Alpers’ contrast between the Italian perspectival and Northern “antiperspectival” view, associating the latter with the camera obscura. Here Jay made perspective and the camera obscura synonymous in their effects. His three claims were once again misleading. If perspective was by nature atemporal, why was its development so closely linked with the development of narratives of the saints’ lives and history painting? If perspective was decorporealized why was it connected with the rise of realistic anatomical representation? If perspective was necessarily transcendental, why was it so closely connected with the rise of individual, personal representation? These were precisely the three characteristics which, according to Jay (187), were affected by changes in philosophy at the beginning of the nineteenth century: “The first concerns what can be termed the detranscendentalization of perspective; the second, the recorporealization of the cognitive subject; and the third, the revalorization of time over space. In all these ways, the status of visual primacy was brought into question.”

According to Jay perspective not only involved an emphasis on space rather than time but also an imposition of space onto time (195): “The successful extension of this spatialization of time, often linked to the dissemination of the same bourgeois practices that fit so well with the triumph of Albertian perspective, reached its apogee in the nineteenth century.” He discussed (208), Bergson’s distinction between spatial presence (quantitatively homogeneous) and temporal deferral (qualitatively heterogeneous); suggesting (275), that Heidegger’s two modes of vision could be defined in terms of Levin’s distinction between assertoric gaze (abstracted, monocular, inflexible, unmoving, rigid, ego-logical and exclusionary) and alethic-gaze (multiple, aware of its context, inclusionary, horizontal and caring). Jay (206), claimed that Gleizes and Metzinger, in their book, *Cubism* (1912), influenced by Poincaré, “helped justify the abandonment of linear perspective in favour of a more qualitative, intuitively derived notion of spatial representation”. Subsequently, he cited (585) Lyotard’s characterization in *Les
immatériaux of the modern as emphasizing space and vision sense whereas the postmodern as emphasized time and hearing.

Jay’s quest to demonstrate that the twentieth century became increasingly anti-visual led to some intriguing interpretations. For instance, he (244) cited a passage from the surrealist, Breton: “it is impossible for me to consider a picture as anything but a window, in which my first interest is to know what it looks out on” and concluded that he was referring specifically to an interior model rather than ordinary vision. He referred (255), to the work of Harris Smith (1984), concerning The surrealists’ windows. In the case of Magritte, he argued (400) that: “The orders of the visible and the sayable, most explicitly at odds in the similitudinous discordance between Magritte’s images and their mysterious titles, thus demonstrates a ‘non-relation’.

The thrust of Jay’s argument was that the word became more important than the image. Among many others he cited (374) Ellul’s praise of Debord for his “religious defence of the word against the image.” He implied that this was much more than a simple question of fashion or choice. He referred (291), for instance, to Sartre in claiming that: “not even a God’s eye view would provide a perspective on the whole.” He noted (374) that Althusser “identified ideology as a reliance on sight of any kind” and explained (419): “That visual experience would become a major battlefield in the service of revolution was inevitable, because of the strong link between any critique of fetishism, Marxist or otherwise and idolatry.”

One would expect that the consequence of anti-ocularism would be a complete rejection of visual imagery. Yet, paradoxically, he dwelt at length (360ff.) on Lacan’s discussions of anamorphosis, particularly with respect to Holbein’s Ambassadors. Moreover, he devoted no less than twenty nine pages to mirrors, referring to various studies studies on mirrors including (31), Gasché (1986), The tain of the mirror, and (458), Kristeva (19** Ellipsis on fraying and specular seduction (Ellipsis sur la frayeur et la séduction spéciale).

The main part of he book was an attack on authors such as Ivins (1946), and Greenberg (1965), who had insisted on the importance of vision for western civilization or, as the jargon holds, its privileging. Jay’s claims seemed so compelling because he drew on evidence from a wide range of disciplines including art history, literature, anthropology, philosophy, marxism, cultural studies, cinema, feminism and history of science.

With respect to art history, he relied on early works in France by Francastel (1951), Painting and society, and Francastel (1963), “Destruction of a plastic space”, who had traced the rejection of perspective and vision in the twentieth century; mentioning (161) the contributions of American art historians such as Steinberg (1972), Fried (1980), Absorption and theatricality, and Alpers (1982). He also mentioned (51) the English art historian, Bryson (1981), in Word and Image. French painting of the French regime, and Bryson (1983), Vision and the Painting. The logic of the gaze (1983), who attacked Sir Ernst Gombrich because he had a perceptual rather than a conceptual approach to art history. Other art historians cited were Foster (1985), Recodings: Art spectacle, cultural politics, Burgin (1986), The end of art theory, and Krauss (19**), Originality of the avante garde. With respect to literature he referred to Bakhtin (444), and Jakobson (351, 371, 447).
In anthropology, Jay blithely overlooked the statements of Levi Strauss concerning perspective and point of view (see above p. 181) and insisted instead that (371) his “general stress on language over perception fit well with the larger trend traced in this book.” In cultural studies, he mentioned the work of Argyle and Cook, (1976), Gaze and mutual gaze, and Foster, (1988), Vision and visuality who distinguished between a “natural and cultural component of vision”.

In philosophy, he cited Wartofsky (1972, 1979, 1980), who claimed that “all perception is the result of historical changes in representation”. Jay interpreted Merleau-Ponty’s (1986), Visible and the invisible, as evidence that he was against vision. He noted Mitchell’s (1986), distinctions whereby image can mean “optical, graphic, perceptual, mental, verbal phenomena” and referred to De Duve (1991), Pictorial nominalism. Of Marxist philosophers, he cited Marx, the art historian T. J. Clark (1984), Jameson (1981), The political unconscious: narrative as a socially symbolic act, and Jameson (1992), Signatures of the visible who argued that (1) “The visual is essentially pornographic, which is to say that it has its end in rapt, mindless fascination”.

In cinema studies, Jay referred to Debord (1967), Comolli (1985), “Machines of the visible”, and Sitney (1990), Modernist montage: the obscenity of vision in cinema and literature. He cited (459) Bazin (1967), who claimed that “the tyranny of Cartesian perspectivalism, which dominated Western painting was lifted as the picture frame, separating subject and object, was replaced by the movie screen, helping to bring them once again together”; (470) Daney’s (1979), assertion “The cinema is thus bound up with the Western metaphysical tradition of seeing and vision whose photological vocation it realizes”, and (473) Pleynet’s claim that: the film camera is an ideological instrument in its own right, expressing bourgeois ideology before expressing anything else... It produces a directly inherited code of perspective, built on the model of the scientific perspective of the quattrocento”.

With respect to feminism, Jay (535), cited the claims of Irigaray (1975):

Within this logic [that of western thought], the predominance of the visual, of the discrimination of form and individualization of form is particularly foreign to female eroticism. Woman takes pleasure more from touching than from looking and her entry into a dominant scopic economy signifies, again, her consignment to passivity: she is to be the beautiful object of contemplation.

Jay also accepted (536) Irigaray’s interpretation of Plato’s allegory of the cave in book six of the Republic as an escaping the womb in which: “the properties of the eye, of mirrors- and indeed of spacing, of space, time, of time- are dislocated, disarticulated, disjointed, and only later brought back to the perspective free contemplation of the truth of the Idea.” On several occasions Jay referred to the work of Rose (1986), Sexuality in the field of vision . He did not however cite feminist anthropologists such as Martin (1990) who: “deplore the supposed tyranny of vision based on the optical appropriation of the thinglike data and choose to leap instead into an invisible realm by studying narrative”.

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With respect to history of science, Jay (389) argued that “Scientific evidence as understood by Bachelard, Canguilhem and later Foucault, would no longer be connected innocently to its root in *videre*, the Latin verb ‘to see’, for what we see is mediated by the cultural construction of our apparently natural perception.” He noted how Foucault had identified (390) “specific visual regimes in constituting cultural categories”. Jay’s understanding of the ingredients of science were rather contradictory. On the one hand he argued that psychology and psycho-analysis was mainly Jewish and entailed a shift from visual back to verbal modes. On the other hand, he insisted (395), that “Just as psychology was born of the visually constructed notion of the Insane, so to the modern science of the individual emerged from the visual penetration of the dead body.” At one point he (395) noted that “If the history of modern scientific experimentation thus showed Foucault that the privileging of vision and the suppression of the linguistic led to a problematic epistemology whose inadequacies phenomenology could not remedy, perhaps modernist literary experimentation might provide a viable alternative”, without explaining precisely what literary theory could or did contribute, except in negative terms (398):

> While the modern discourse of science sought to efface language in favour of the empirical gaze, thus fostering a mistaken belief in the veracity of observation, modernist literature exemplified by Roussel restored the unsublatable dialectic of saying and seeing in which neither overcame the ‘muteness of the object’

At the same time Jay (398) cited passages such as the following from Foucault (1963): “combining the vertical point of view (which permits everything to be embraced as in a circle) and the horizontal point of view (which places the eye at ground level and gives to sight only the first dimension) so well that everything is seen in perspective and yet each thing is envisaged in its complete context”. How this was proof of Foucault’s anti-ocular approach was not explained. Instead, Jay (404) noted Foucault’s claim that “The triumph of natural history was thus the triumph of a new visual order,” and drew attention (406) to Foucault’s analysis of Velazquez’ famous painting:

> man appears in his ambiguous position as an object of knowledge and as subject that knows; enslaved sovereign, observed spectator, he appears in the place belonging to the king which was assigned to him in advance by *Las Meninas*, but from which his real presence has for so long been excluded

He (441) also recalled a definition of science by Barthes: “Science interprets the gaze in three (combinable) ways: in terms of information (the gaze informs); in terms of relation (gazes are exchanged); in terms of possession (by the gaze I touch, I attain, I seize, I am seized)”.

With respect to technology, Jay (415) cited Deleuze’s claim that Foucault feared the “disciplinary society of the panopticon was being replaced by a new society of control based more on computerized than visual surveillance,” as well as (593) Serres’ (1989), assertion that “contemporary modes of communication, based on codes and computers have put an end to the reign of panoptic theory.” He referred (502) to Derrida’s *Writing*, claiming that: “The nineteenth century panaoramagram invented by Emile Littré to show objects on a flat surface in their true visual depth, was, Derrida insisted, the very image of the structuralist instrument”, and he also believed (591), that Crary (1990), “has so
persuasively shown, it was not long ago that scientific certainties about visual experience were overturned in favour of others”.

Psycho-analysis was another field cited by Jay to argue for the demise of vision in twentieth century French thought. Here Freud was considered important, for (334): “Although there were visual representations in dreams they had to be rearticulated in linguistic form before they became available for analysis.” Lacan was discussed at length. Indeed, Freud and Lacan were cited as sources of Althusser (1964), in the context of structural marxism, yet another field that contributed to anti-ocularism.

Jay noted Hebrew connections and referred to two books by Rassial (1981, 1985): *Is psychoanalysis a Jewish story?* and Rassial (1985), *The interdiction on representation (L’interdit de la représentation)*. Evidence of these Hebraic connections in the United States (Blatt) and Britain (Gablik) was considered in another context (see above p.8-10*). These Hebraic connections are the more striking because Jay (22, 43) argued that anti-ocular debates were part of a larger clash between cultural traditions, namely, Greek vs. Hebrew; that the Greek tradition emphasized the visual whereas the Hebrew tradition emphasized the verbal; one seeing, the other hearing, and (35) that the rise of protestantism, notably through Luther and Calvin, marked a return to Hebraic concerns with the verbal and hearing.

He claimed (269), that Heidegger had re-introduced an Hebraic emphasis and cited Jonas’ assessment that through Heidegger “the suppressed side of hearing gets a hearing after the long ascendancy of seeing and of the objectification which it cast upon thought”. Jay also drew attention (499, 517) to Derrida being Jewish who, along with Lyotard, claimed that “both Kant and Hegel associated the sublime with the Jewish taboo on representation”. Jay believed (546), that a study of “Levinas will help reveal the unexpected links between the traditional iconoclastic Jewish attitude toward visual representation and a powerfully antiocular impulse in postmodernism”.

In his conclusion, Jay returned to a more careful stance. Instead of claiming that perspective had disappeared entirely, he suggested (545) that postmodernism was “suspicious of single perspectives which, like grand narratives, provide totalizing accounts of a world too complex to be reduced to a unified point of view.” Indeed, in the end he returned to visual metaphors in describing his aims (592):

> When ‘the’ story of the eye is understood as a polyphonic- or rather, polyscopic - narrative, we are in less danger of being trapped in an evil empire of the gaze, fixated in a single mirror stage of development, or frozen by athe medusan ontologizing look of the other. Permanently ‘downcast eyes are no solution to these and other dangers in visual experience.

One senses that if only Jay had been more aware of the complexities of twentieth century vision he would have felt less compelled to outline its theoretical demise. It is instructive to contrast Jay’s conclusions with those of Gesell (1950) concerning infant vision (3):

> Babies grasp the world first with their eyes and then with their hands. ision is therefore a prime constituent in the development of the total child....
Our civilization is becoming increasingly eye-mind. The demands of growing children are multiplying and intensifying. The conservation of vision, therefore has become a task of vast social dimensions.

6. New Media

The rise of new media, notably, holograms, television, cinema, modern theatre, computer hardware and software and virtual reality, has brought a series of further transformations to the window principle.

Holograms

Although usually produced by a combination of light sources from two different viewpoints, holograms have the curious property that their spatial effects are only visible from a given viewpoint. When viewed from other positions a hologram reveals only its surface, which typically contains a completely different image. Some artists have been content to draw a fully flat two dimensional image for these views which is then transformed into a three-dimensional image when viewed frontally. The shapes chosen for the three dimensional images frequently include regular solids, a hypercube, chairs or other semi-regular shapes familiar from perspective treatises (pl. 125-126).

Some artists deliberately treat the surface of the hologram as if it were a window. In some cases these hologrammatic windows are covered with a grid in the manner of traditional perspectival windows (pl. 127-128). Some artists, including Salvador Dali, have used holograms as a means of extending the explorations of ambiguities of space introduced by the surrealists, with the result that the window reveals walls that are themselves potential windows.

Television

Traditionally the television screen has functioned as if it were a window, allowing us to see into a room or out onto a landscape. A new technique was introduced by CNN at the time of the Gulf War (1991) whereby this window effect used to show the reporting room was complemented by a further window onto the battlefield.

Cinema

The cinema implicitly introduced new paradoxes by using an interior screen as if it were a window onto an outside world usually very different from that surrounding the cinema. In cases of the IMAX and its more complex relatives such as the OMNI-MAX and Magic Carpet cinemas this surrounding window becomes so encompassing that what had been an opening into the exterior is transformed into an artificial exterior, which was well documented in a film aptly named, Putting you in the picture.

In a number of cases the cinema also introduced a new level of play into the window concept by exploring the transparency principle in terms of mirrors, a phenomenon to which Roman Gubern (Barcelona) drew attention in a fascinating video (fig. 87):

<table>
<thead>
<tr>
<th>Film</th>
<th>Director</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Circus</td>
<td>Charles Chaplin</td>
<td>1927</td>
</tr>
<tr>
<td>Los hijos de la noche</td>
<td>Benito Perojo</td>
<td>1939</td>
</tr>
</tbody>
</table>
How to Marry a Millionaire  Jean Negulesco  1953  
Citizen Kane  Orson Welles  1941  
The Lady from Shanghai  Orson Welles  1947  
Le sang d’un poète  Jean Cocteau  1930  
Orphée  Jean Cocteau  1950  
La novia de la marina  Benita Perojo  1948  

Fig. 87. Films with an emphasis on mirrors collected in Roman Gubern’s documentary on *Mirrors and virtual space in the cinema* (1927-1953).

Spielmann (1993) claimed that a shift from analogue to digital film implied a return to pictural traditions: i.e. a greater spatialisation of the moving image, variability of the frame function; as well as a shift and greater density of successive montages, with a re-animation of frozen moments of motion. She distinguished between transparent and opaque image carriers and drew attention to new effects such as the camera pinceau and the camera as paintbox. Drawing on ideas of Deleuze and Jameson (1991), she claimed that the postmodern crisis of historicism entailed a new spatialisation of the temporal and that the cartography of perception and knowledge (cognitive mapping), entailed a characterization of navigation that was predestined for electronic media. Spielmann explored the implications of the new media for concepts of the window and the mirror:

> Scenically the video monitor functions as a window wherein, however, no actual external image is seen, but rather a secondary level of mediafication is presented....The mirror image contains a double visual metaphor. Diegetically this framed image is beholden to the principle of the abime (mirroring of that which is outside). Nonetheless, with respect to the televisionary status it acquires the extra-diegetic function of an inference whereby the random addition of other images remains contained in the format.

Spielmann focussed on the work of Peter Greenaway, notably the *Draughtsman’s Contract* (1983), and *Prospero’s Books* (1991), to suggest that his work entailed a return to techniques originally developed in Renaissance painting. (fig. 88) and a new emphasis on a visual cluster with:

> a simultaneity that appears as an inner image, a layering of diaphanous image planes and electronically supported strives to absolute, punctual concentration. Inference contains serial, successive and other continuous procedures in a new montage form, in short to a cartographic image space. The metaphors of a web-frame (Deleuze) and of spatialisation (Jameson) experience a concrete transaction in Greenaway through the accumulation of the frame function and its concentration to a cinematic image cluster.

Renaissance Painting and Digital Film  
Analogue Film  
Central Perspective  
Multi-Perspective  
Static Image  
Moving Image
Centripetal     Centrifugal
Fig. 88. Parallels between Renaissance painting and digital film with contrast to analogue film. according to Spielmann (1993).

In essence, Spielmann suggested (61) that once film was freed from the need of mirroring, it comes into its own and becomes conceptual. Following Steinberg (1972, 84) she claimed (64) that a shift in the picture plane from vertical to horizontal marked a shift from nature to culture.

Spielmann (1994), returned to these themes, claiming that if film was seen as a solution to the space-time limitations of painting, electronic images raised these questions anew, particularly with respect to three problems: framing, fading and the concept of the fake. Again Greenaway’s films were used as examples. Instead of suggesting connections with Renaissance perspective, she now suggested that there were similarities with cubist painting, in that Greenaway’s technique “avoids the illusionistic spatial depth and point fine of renaissance painting” and moves towards “aperspectivity and aviatic optics”. Cezanne’s move toward multiperspectivity was compared with montage techniques in film. She noted also that the camera angle in *Vertical features remake*, instead of distorting the perspective, gives an unlikely point of view analogous to Rodtchenko’s formalist position.

Perhaps the most provocative claim was with respect to “fake” which Spielmann related to seeing, knowing and false knowing (erkennen). She noted that the optical device in the *Draughtsman’s contract*, entailed a misunderstanding of perception as apperception; that the *Belly of an architect*, was an exploration of relations between original, photography and photocopy to conclude that reproductions do not necessarily lead to a reality check. Hence (144), a fake was not necessarily either a reproduction nor a link with an original copy. It could readily be “an image without correspondence to an original.” To illustrate this she cited how Vermeer’s *Art of painting*, in a *Zed and two noughts*, served as a starting point for a fake that was an original work in the style of Vermeer. It is significant that the article was subtitled “The art of rules”, in contrast to another school which fears that rules destroy art, and will be noted that Spielmann’s concept of the “fake” is another formulation of the principle of non-correspondence discussed above.

**Modern Theatre**

Traditionally the theatre has been faced with the problem of keystoning, a type of anamorphosis that occurs when an image is projected onto a wall at too sharp an angle. A typical solution was to position the projector in a position where its image was more likely to be frontal, i.e. one avoided the problem.

Since 1990, experiments based at Cornell University have explored a new solution to this problem. When a regular image is projected at a sharp angle and/or onto an irregular surface, the resulting distortions are recorded. These distortions are then used to create a distorted original image which, when projected at an angle, appears correct. In other words rather than worry about possible distortions of an original image when projected, one deliberately takes these potential distortions into account in the original such that when this distorted original is projected it has the same effect as the undistorted image
from which one began at the outset (pl. 115-116). As will be noted this represents an important trend in image manipulation.

**Computer Hardware and Software**

Drawing packages for computers have developed so-called paint programs. Initially these were limited to imitating the effects of a paintbrush such that one could take an image and add colours to it as one wished. Since 1988, there has been a new trend in popular packages to create a series of special effects algorithmically. A Toronto based firm, Image Ware, which sells its products through the U. S. based, Aldus Pagemaker has, for instance, created algorithms for producing craquelure effects in a photograph of a scene or a painting automatically. In 1991, they began on a technique that would automatically transform an image in linear perspective to one in spherical perspective. Silicon Graphics machines already have this feature. Hence these new algorithms allow transformations from one kind of window to another: linear to spherical etc. By implication regular pictures can be transformed automatically into their anamorphic equivalents and conversely.

In the early days of their development it was frequently assumed that computers were merely a further example of another media. It is important to recognize that much more is involved. Earlier media regularly came with a rhetoric assuming that the new would replace the old. Hence, the introduction of papyrus was supposed to supplant cunieform tablets, the introduction of manuscripts replaced papyrus and the invention of printing was supposed to replace manuscript culture. Each of these new media called for a “simple” translation of the message from one medium to another. Computers are different. First the translation operation, which typically involves some scanning device, is only one step in the process. A second step entails electronic recognition of the parts such that one can edit, manipulate, and transform the original text. A third step entails taking that digital text and printing it out, i.e. back into print media. That which applies to words is being increasingly applied to pictures. Early versions used only two dimensional pictures.

The latest three-D laser camera of the National Research Council of Canada allows this operation to occur in three dimensions. An object such as a jar or mask can be photographed from all sides, such that its image on the screen can be viewed from all sides. This image can in turn be “printed” in three dimensional form using methods akin to stereo-lithography. Other media are being added to this process such that one can take an audio input, translate it to a digital form and then reproduce it either as an audio or as a verbal print output. In short, the computer is introducing a potential interoperability and translation process among all the media rather than a simple exercise of replacing one form by or with another. Many persons who speak of multi-media with respect to computers are not aware of the full implications of that term.

**Virtual reality**

Virtual reality is greatly expanding our conceptions of the window both as tool and as image. In what was effectively a forerunner of this new technology, Myron Krueger used
a virtual window in his Videodesk program. But instead of drawing on the surface of the window, he simply used it as a plane behind which one could draw images. The separation between the drawer and the object drawn which characterized Renaissance perspective was here transcended in an experience whereby one could at once draw on the window and manipulate the space represented by the window.

The head mounted display version of virtual reality (cf. above pp. 143-149*) involves two television screens which function as two windows into scenes. Given their extreme closeness to the eye these scenes would appear distorted if they were true to life. By way of compensation, the scenes are deliberately distorted in order to appear regular when seen by the two eyes. This it will be noted is conceptually analogous to the anti-keystoning effects that are being introduced into theatre projections. Rather than have us experience the distortions that occur with regular images, we are expected to view images distorted in such a way that they will appear correct when seen from a given place.

<table>
<thead>
<tr>
<th>Method</th>
<th>Production Instruments</th>
<th>Viewing Instruments</th>
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<tbody>
<tr>
<td>Perspectival painting</td>
<td>Window, Dark chamber</td>
<td>Opaque surface</td>
</tr>
<tr>
<td>Photography</td>
<td>Lens, Dark chamber</td>
<td>Opaque surface</td>
</tr>
<tr>
<td>Holography</td>
<td>Laser, Dark chamber</td>
<td>Transparent over opaque surface</td>
</tr>
<tr>
<td>Computer</td>
<td>Computer, Screen, Software</td>
<td>Computer, Screen, Software</td>
</tr>
<tr>
<td>Virtual Reality</td>
<td>Computer, Screen, Software</td>
<td>Computer, Screen, Software</td>
</tr>
<tr>
<td>Cameras</td>
<td>Television Screen</td>
<td>HMD, Glove</td>
</tr>
</tbody>
</table>

Fig. 89. Basic methods and the technologies required for their production and viewing.

Each step towards a more complex technology has introduced more instruments for both the viewing and the production of images. Hence as the window technique became more effective, a greater technical wall interposed itself between viewer and object (fig. 76). During the Renaissance, artists used linear perspective to represent a static space in a picture as determined by the position of a viewer looking at the scene from a given viewpoint. In virtual reality much more is involved. First, artists use perspective dynamically to create different spaces of the picture such that one can see how the relative sizes and positions of objects change as one travels through this space. Second, as one’s viewpoint in this space changes, one can move different persons and/or objects at will. Third, one can move through the space from the viewpoint of a person or an object such as an automobile moving through this space. Fourth, one can move through this space at a set distance from such a moving person or object. For instance, the World Editor in Dimension International’s software584 includes a plan view, perspective view, a North, West view and an East, South view (fig. 36). These possibilities, it will be noted, are a direct consequence of the innovations in computer graphics examined earlier (see above pp. 135-143). Hence, whereas Renaissance perspective was concerned mainly with the static space of the picture, recent developments in virtual reality integrate dynamic views of observers in their picture space. Which is one of the reasons why virtual reality has also played a major role in expanding the scope of perspective.

Canada Future scenarios building on the present
Europe Historical and projected objects with real landscapes
Japan Futuristic scenarios independent of present
United States Fictive scenarios blurring present and future.
The possible uses of virtual reality vary with different cultures (cf. fig. 77). In Japan, the trend of cartoon films such as *Akira* (1987) and Sega games involve highly imaginative futuristic city-scapes with little reference to actual buildings in everyday experience. In Europe, there has been a trend to use virtual reality as a means of linking imaginary images with physical reality. A project by Renault superimposes a computer image of a prototype car, the Racoon, onto a real landscape\(^\text{585}\). A project at the ETH in Zurich uses virtual reality to visualize real Roman ruins such as Aventicum, or the underlying structures of mediaeval monasteries\(^\text{586}\). An Italian project by Antinucci, called the *City of Giotto*\(^\text{587}\), uses virtual reality to re-construct the Upper Church of Saint Francis at Assisi such that one can go down (or up) its aisles, enter the space of any of the frescoes on the walls and explore their features. A virtual reality project of the Gesellschaft für Mathematik und Datenverarbeitung (GMD now Fraunhofer) at Schloss Birlinghoven reconstructs the interior of the castle, but warns: “What you see is never what you get”\(^\text{588}\). Another project of the GMD reconstructs a pulsating human heart and allows one to change one’s views of sections in real time.

This European concern with visualizing hidden elements of existing physical structures is paralleled in Canada by a concern with visualizing potentially physical structures: hence more concern with design of future buildings than with the study of past buildings (often for purposes of conservation). In this respect Canada is closer to traditions of Europe than of the United States. The software of companies such as Alias and SoftImage typically serves as a tool for heightening our understanding of planned, existing, and possible objects rather than in creating visions with no (possible) basis in physical reality\(^\text{589}\).

Whereas Europeans and Canadians often focus on visualizing external objects, there is a trend in the United States towards visualizing processes that would otherwise be invisible\(^\text{590}\). Some, such as Robinett\(^\text{591}\), see virtual reality as an electronic expansion of human perception. More often, virtual reality is treated as an environment in which one can be immersed such that it can be seen as a direct extension of illusionistic worlds such as *Back to the Future* at the Universal Studios theme park and more generally of the celluloid recreations of Hollywood. Opinions differ concerning the extent to which this can imitate physical reality. For instance, Aukstakalnis and Blatner are convinced that it will not:

> be possible to create realities so clear and complex that we won’t be able to perceive the difference between our everyday reality and a computer generated one....But the worlds that we use computers to create may eventually be so realistic, so enticing, and so interesting that we may intensely want to believe in them and they will become like mirages in the desert\(^\text{592}\).

Others, such as Pimentel and Teixeira, are more optimistic concerning the power of computers to simulate realistic effects:

> Virtual reality is all about illusion. Its about computer graphics in the theatre of the mind. Its about the use of high technology to convince yourself that you’re in another reality, experiencing some event that doesn’t physically exist in the world in front of you....Simply, virtual reality, like writing and mathematics is a way to
represent and communicate what you can imagine with your mind...and it can be shared with other people

In this view virtual reality is the best means of externalizing the contents of the mind, an ultimate tool for exteriorization, for perfecting the extrovert. Ironically in a culture where the passive tendencies of television are a dominant mode, there is a danger that this tool for externalizing the interior, becomes a weapon for imposing onto the internal minds of most the carefully crafted external views of some few. This is a major problem.

At a subconscious level there are further dangers. In the past, myth was traditionally one of the binding features of a society. This frequently occurred in communal settings with a shaman or elder in a storytelling mode. Myths delved into the collective memory of a tribe or culture and used this experience to join members together. While verbalized and voiced in stories they remained largely internalized, insomuch that speaking about them in detail was reserved for a few individuals. In the latter twentieth century, myths, to the extent that they still exist, are being increasingly visualized and externalized in the form of video games, and role playing game such as Dungeons and Dragons. The imagery is increasingly personalized such that the adventures may link the individual participants but at the same time separate them from their other contemporaries.

By externalizing and rendering public what was traditionally the domain of a few individuals, there is a danger that the mythic and the real worlds will be confused in new ways: that persons will attempt to live mythically in the so-called real world, that spaces of myth and spaces of the physical world will be conflated. In retrospect, we can see that the Renaissance, which used perspective to externalize religious narrative, also posed a threat to continued belief in their efficacy. Will the same prove true with myth in the late twentieth century? Or will this externalization of more elemental aspects of our semi-conscious traditions have more profound consequences? In any case, of interest for our purposes is that the European, Canadian, Japanese and American interpretations of virtual reality all entail extensions of perspective. Hence virtual reality is yet another reason for the rebirth of perspective in the latter twentieth century.

7. Objectification of the Subjective

Erwin Panofsky, in *Perspective as Symbolic Form*, summarized the achievements of Renaissance perspective as resulting in: “a translation of psychophysiological space into mathematical space; in other words, an objectification of the subjective.” We have suggested that this is not true: that Renaissance thinkers did not abandon their theories of psychophysiological space. They assumed that their theories of vision coincided with the principles of mathematical space that they applied to representation. In some of the stock cases that they used for demonstration the two did indeed coincide. And when thinkers such as Bosse confronted them with discrepancies between perspectival representation (in terms of projections) and Euclidean theories of vision (in terms of visual angles) members of the French Academy chose to abandon the strict principles of Renaissance perspective rather than those of Euclidean theories of vision.

If Panofsky was wrong in his analysis of Renaissance events, his mention of “objectification of the subjective” identified a very important tendency of his own time. We have shown that this concern has continued to gain in importance since the mid-
nineteenth century. In the latter twentieth century these trends have taken on a new level of significance. In a sense we have gone back to the Greek tradition which adjusted the shapes and sizes of objects in order that when viewed from a correct position they would look correct, the difference being that we now have reversible methods that allow us to move interchangeably between objective original and subjective versions.

We now have traffic signs in a deliberately distorted anamorphic form on our streets in order that they will look correct when seen from the extreme angle of an approaching automobile driver. The preplanned distortions of a theatre image that looks correct after it has been keystoned; or the deliberately distorted images of the cameras on a head mounted display that look perfectly correct when seen from nearby, are two other manifestations of this trend. The window, which began as a tool for recording an objective world, has increasingly become an instrument whereby images of the objective world are transformed into subjectively convincing surrogates of objectivity.

Animations were traditionally moving versions of given objects and persons. Recent developments have changed their function. Animations are increasingly becoming transformations from one person or object into another. The process is called morphing. We see it in the advertisements of a girl’s face that changes to that of boy; a black person into a white person; a youth into an old man and conversely. On the surface these transformations are as intriguing as they are clever. At the same time they pose difficult new philosophical problems. How is one able to identify which is or was the original object or image on which the transformations were based?

In the Renaissance the window was an instrument that fixed a relation between an original object and a representation of that object. In the past century the window offered a means of transforming this representation of an object into a subjectively convincing image. In the past decade these transformative features have so much come into focus that it is well nigh impossible to trace the object that was the point of the departure for a series of images. Indeed with the rapid development of Computer Aided Design (CAD), and graphics packages that permit complete intervention, it is no longer possible to know whether there even exists an original object or whether the image sprang directly from the image-ination.

8. Space-Time

9. Re-contextualization

During the Renaissance, perspective aimed at a representation that potentially copied an image of the physical world such that it created a coherent illusion of that physical world. Initially this quest involved mainly the medium of paint. By the Baroque period sculpture and architecture had been integrated within this framework and one could argue that the next centuries saw an extension of these principles culminating in the Viennese concept of the comprehensive work of art (“Gesamtkunstwerk”).

Not all art followed this ideal. Already in the sixteenth century there was a practice of combining elements of a series of ruins in a single composite picture. By the seventeenth century this had become the fashion in the art form known as capriccios. Even so these
fanciful combinations remained within carefully defined limits. For instance, Pannini combined a series of Roman ruins in one painting and a series of modern Roman buildings in another. The capriccios shifted the physical locations of buildings. They questioned neither the principles of creating coherent illusionistic views of buildings nor of revealing the source of the original image. Even when it was hidden, the visual equivalent of a footnote or reference was always in place.

The electronic versions of perspectival space have brought fundamental changes to this process. They entail a fragmentation in the process of creating illusion and amount to removing this implicit footnote to the original object in the physical world. In its simplest version an image of a location in the physical world may have superimposed on it an image from the world of animation as in Roger Rabbit or Terminator 2. Conversely, a computer animated space may have superimposed upon it the figure of a live person from the physical world as also happens in Roger Rabbit and more dramatically in Kurosawa’s Dreams where a modern spectator in a museum walks into two paintings of Van Gogh. In both of these cases the illusion of the context is quite separate from and provides no hint concerning the source of the isolated figures within them. Traditionally there was a challenge of making classical quotations which could and would be recognized. Notwithstanding, isolated demonstrations in the Hitchcock pavilion at Universal Studios, and occasional studies on the subject, the modern art appears to be in hiding the source (ars est celare artis in a new sense). Indeed, special effects have become the main theme of movie series such as FX (1986, 1991), and play a serious role in other movies such as Darkman (1991), Lawnmower Man (1992), and Ghost in the Machine (1994).

Multi-media increases this process of fragmentation. For instance, in the preparation of the first full-length feature computer-animated film, an adaptation of Jules Verne’s, Twenty Thousand Leagues Under the Sea (1995), Channels software of SoftImage is used to copy information from sensors attached to the face of a live actor onto the face of a computer generated figure. As a result the facial expressions of this computer animated version of Captain Nemo are perfectly “realistic” but there is no way of knowing the source of this realism, namely the facial expressions of a given live actor (pl. 143-144).

<table>
<thead>
<tr>
<th>Process</th>
<th>Physical World</th>
<th>Virtual World</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channels Software</td>
<td>Sensors on Face</td>
<td>Movements on Face of Model Figure</td>
</tr>
<tr>
<td>Virtual Reality</td>
<td>Turning Head</td>
<td>Turning Head</td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>Moving Glove</td>
<td>Moving Body</td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>Moving Other Parts</td>
<td>No Effect</td>
</tr>
</tbody>
</table>

Fig. 91. Some examples of correspondences and non-correspondences between actions in the physical and the virtual world.

With virtual reality this fragmentation process is even more complex. Hence turning the head in the physical world leads to a corresponding turning of the head in the virtual world. Turning the hand within a data-glove leads to a corresponding movement of the virtual body. Other systems use a hand controlled space-ball to introduce six degrees of freedom with respect to movement. In the case of other parts of the body there is no correspondence between motions in the physical and virtual worlds. As a result a beginner experiences considerable confusion because correlations are neither intuitive nor systematic.
In the case of books and articles, scholars have developed the use of footnotes and references to document these sources and as a means of checking the reliability of any claims made. In the case of images, captions served an equivalent function. Because the medium of print brought to words and images a stability with respect to content, if changes were made they were documented clearly as a revised or new edition. Hence, footnotes, references and captions sufficed as tools for establishing the authenticity of claims.

Electronic media are transforming our abilities to edit collections of words and images. An article or book written in a word processing package such as Word or WordPerfect can all too easily be amended. If such texts are online how are we to know which version is being cited? At present backups are dated but this information does not usually appear in printouts. We need new techniques that document the time of changes and new ways of archiving earlier versions of texts. We need electronic equivalents for revised versions and new editions. Workflow software such as Digital’s Linkworks version manager allows one to see who modified which details when. This software also provides a series of seven different levels of access to materials. These standards being introduced to the corporate world need to be adapted by the scholarly world.

Similar problems obtain in the case of Computer Aided Design packages which presently enable users to edit and transform images. Parts of a scene can readily be taken and integrated elsewhere to form new composite pictures and hence these new tools have contributed considerably to the fragmentation of illusion noted above. At present image editing software such as PhotoShop, PhotoStyler or TBase offer choices in terms of image resolution (e.g. 1024x768 or 640x480), dithering, filtering, resampling and scaling. However, once an image has gone through these transformations they are not recorded on the image. Needed is a set of captions, which might usually be invisible, that documents technical characteristics of the original image and changes that it has undergone.

Some of the attendant difficulties these image editing programs introduce with respect to certifying the veracity of images have been the subject of an important recent study by Mitchell and are currently a subject of discussion on the Internet. Meanwhile, firms such as Kodak have been investing considerable energies to introduce hidden methods for determining whether or not an image that began as a photograph has been altered. Without such precautions the uses of photography in legal evidence would soon disappear.

If images are to retain their scholarly as well as their legal respectability it will prove useful to adapt other techniques that have been developed in the case of textual studies. For instance, scholars of manuscripts (codicologists and palaeographers) have devised subtle tools for determining which manuscript was copied from another manuscript in order to arrive at the equivalent of family trees (stemma) of tradition. Corresponding pedigrees of images are needed such that one can determine (where possible) the number of generations they are removed from the original, analogous to the way that one distinguishes among different states of engravings (fig. 79). In addition to this we need to know who owns (or owned) the copyright to each of these generations. Only then will we be able to write captions that serve as equivalents to footnotes in the realm of images.
Fig. 92. Pedigree of an image defined in terms of numbers of generations between the original and its digital version.

Using such a system for determining the pedigree of an image, museums and galleries might decide that only second and third generation images fall within their purview and are subject to copyright controls with respect to reproduction. Hence images beyond three generations would not be acceptable as “official” images. In future it might be decided that new scholarly claims should only be made on the basis of such official images.

In a penetrating study on Renaissance wall paintings Sandström distinguished between different levels of unreality. An electronic equivalent is needed such that a user can see how many levels an image on the screen is removed from the physical world (fig. 80). Some of these levels such as geometrical figures would be further divided into different modes, such that one could distinguish between those which were drawn by hand, by instrument, and electronically. The introduction of such levels would have a further advantage of providing a new sense of context for various images and versions of objects.

1. Original   Physical Object
2. Model of    “    “
3. Photograph of “    “
4. Drawing of   “    “
5. Geometrical Figure of “    “
6. Algebraic Formula of “    “

Fig. 93. Levels of abstraction seen in relation to the media used to record knowledge of the physical world.

In the case of image manipulation we probably need to make a number of further distinctions, namely whether reality was subtracted or added. Professional photographers are all too familiar with photographs of Mr. or Mrs. X in which the light on a pimple or blemish was unflattering. With the aid of finishing techniques, this was quietly removed. Such covering up of unwanted reality is rather different than cases where a figure has been added to a scene in order to put someone in a compromising context. Experts are aware that each medium and each technology leaves its own traces and produces its own particular artifacts (or artifacting as they say). This evidence should be documented and placed in a header file such that it remains hidden under normal situations but can be consulted much in the way that one can turn to endnotes when one is concerned with checking an author’s sources.

10. Conclusions

If we look back over the developments of the past century it becomes clear that perspective did not simply die. As was suggested elsewhere (Sources, pp. 195-204), the goals of art were greatly diversified and for a short time it seemed as if the new non-
representational goals would replace the older traditions of realism and the so-called figurative arts. In retrospect it has become clear that realism has not gone away. Certain cultures may insist that thought, art, or even creativity is primarily conceptual rather than perceptual, some schools may argue that nature and nurture need to be conflated, some may emphasize the role of constructivism, deconstructivism, or even destructivism, others may pose questions concerning the extent to which correspondence theories of knowledge apply in practice and yet realism has not managed to go away.

In trying to understand the larger context within which perspective evolved it was noted that the rise of systematic drawing systems entailed an increasing emphasis on contained spaces which led naturally, as it were, to artifice and ultimately artificial reality. It was shown that this shift had its own social implications. Hence what began as an event that brought together members of the public (of a certain class) in an inclusive sense, gradually became an exclusive performance for an ever smaller circle of persons, which then in turn expanded once again.

It was suggested that developments in twentieth century perspective could fruitfully be seen in terms of a re-evaluation of the principle of correspondence, or rather as a challenge to some of its basic tenets by introducing reversals of the transparency-opacity laws, playing with the idea of windows as walls, and reversing usual assumptions concerning inner and outer. One basic consequence of these experiments was a widening of the categories of correspondence and non-correspondence to include a whole spectrum of alternatives: theoretical, assumed, possible, transposed and no direct correspondence. Experiments with alternative planes furthered this trend as did the introduction of new media. Which led in turn to a much greater fascination with transformations from one kind of system to another, sometimes systematic, sometimes algorithmic, or sometimes purely accidental.

This led to a re-consideration of Panofsky’s intriguing phrase concerning the objectivization of the subjective, which has come to mean something very different from that which he appears to have meant when he first gave his lecture at the Warburg 60 years ago. Perspective, in its new manifestations, is transforming our concepts of space, time and the very concept of representation.

Renaissance perspective was originally a method for demonstrating clear relationships between representations and the objects upon which they were based. As such Renaissance perspective revealed its sources, vaunted them almost. By contrast perspective in the twentieth century has become a game of hiding its sources, veiling its connections with the original, playing with the principle of correspondence, shifting, transforming, denying it until it sometimes becomes impossible to determine the source. Some have used this ability as an expression of freedom, as proof that the spirit is not bounded, limited, hemmed in by any one to one link with the external world, nature, reality. Others have tried to avoid even the mention of all such words, as if one could make that which is outside us go away, only to find themselves haunted by notions such as difference, the other and the like. So there is a new trend towards finding new ways of making relations with things beyond us, a renewed concern with the importance of context and re-contextualization. And in the process we are finding that perspective is something much deeper than a handy convention or a temporary fad. Long ago Kant
recognized that perspective served as a key for both physical and mental orientation. We are learning that it is a tool for conceptual navigation: a way of finding not only where we are, but also for discovering who, what, how and even why we are. No wonder then that perspective, which introduced the notion of an open horizon is such an open field.

VII. NOTES

I. ORIGINS
3 Ibid., p. 94.
5 Sebastiano Serlio, Il Secondo libro della prospettiva, Venice, 1584, fol. 18v: "La prospettiva è molto necessaria all'Architetto, anzi il prospettivo non farà cosa senza l'Architettura, nè l'architetto senza prospettiva."
6 Jacopo Barozzi da Vignola, Le due regole della prospettiva pratica, ed. E. Danti, Rome: Zanetti, 1583, preface: "Se le operazioni maravigliosi della natura, quanto dell'arte, tirarano talmente gli'Uomini in ammirazione, che incominciarono a filosofare, ed investigare cagioni di quelle; meritamente si sono affaticati molti in ricercare la cagione de gli effetti, che accadono intorno all nostra vista per la varietà de'raggi visuali...."
7 Ibid.: "Nè minor cura ho posto in servire alle piu scientifici, i quali, non si soddisfacendo solamente di bene operare, e sapere, che la cosa è così, ma di piu ricercano le cause, e le ragione de'loro effetti."
8 Pierre Francastel, Peinture et société, Paris: Gallimard,1965 ed., p. 13: "une nouvelle conception esthétique de l’espace....Pour Brunelleschil’espace a cessé d’etre lle cube d’air qu’une voute enferme entre ses parois; il possède une qualité homogène et il se trouve partout, il est à la fois contenant et contenu; il enveloppe et est enveloppé "
9 Francastel, 1965 ed., pp. 15, 17: "Il est clair que la découverte fondamentale, celle qui concerne les qualités particulières de la lumière -substance invisible, mais susceptible de se laisser mesurer et manier par l’artiste -a inspiré l’idée non seulement d’un nouveau fonctionnalisme architectonique mais également d’un nouveau système de représentation picturale de l’espace à élaborer. Brunelleschis est l’homme qui substitue à l’évidence plastique du Moyen Age, fondée sur la stéréotomie, la taille et l’assemblage des blocs, le maniement de la lumière enclose, la nécessité d’un autre compartimentage de
l'espace, dans un système qui reproduit une sorte de modèle imaginaire mais qui laisse communiquer entre elles toutes les régions de l'espace....

Ce n’est pas seulement une nouvelle architecture et une nouvelle peinture qui en sont sorties, mais une nouvelle société et presque, matériellement parlant, un nouveau monde. L’intégration des parties concrètes et subtiles de l’univers physique, la foi dans la magie du nombre ont préparé la découverte de l’Amérique, comme la nouvelle jurisprudence fondé sur l’équilibre des Etats."

10 Ibid., p. 209:
"Il ne fait scientifiquement aucun doute que l’art d’une époque est d’avantage que l’expression littéraire d’une société: il se fond sur les structures mentales et physiologiques les plus profondes de l’homme, il n’est pas une superstructure, mais un langage."

"La perspective euclidienne impose une hiérarchisation particulière de l’expérience émotive, où la projection du moi dans l’avant-plan, la masse, la coloration vive, est aussitôt niée par son insertion dans un système abstrait, ou le lointain s’impose comme le terme, le but, le point ou se rejoignent les coordonnées des expériences particulières. Cette équilibration forcée demeure toutefois un modèle artificiel de l’expérience du moi et du non-moi, car elle tend à nier la validité expressive du proche, qui ne constituerait toujours qu’une étape dans un trajet vers le lointain. Elle nie aussi le lointain lui-même, par l’impossibilité de l’affirmer par les moyens picturaux eux-mêmes, qui le rapetissent à le rendre presque imperceptible, qui le voile de zones d’ombres ou de couches atmosphériques confuses, ou encore qui le noie dans une luminosité diffuse. A l’intérieur de ce schéma fixe, aux coordonnées inamovibles, notre civilisation voudrait confiner la représentation que peut se donner l’homme de son expérience -du - moi- dans- le- monde. Il est certain que la survie de l’activité artistique est liée depuis le siècle dernier à un combat continu, plus ou moins ouvert, mais définitif contre non seulement le primat de “l’image” figurative, mais d’une façon plus essentielle en faveur d’un ressourcement, d’une réaffirmation péremptoire des expériences spatiales préeuclidiennes, au niveau des formes primaires et des relations topologiques."

12 Gerard Simon, Der Blick, das Sein und die Erscheinung in der antiken Optik, Munich: Wilhelm Fink Verlag, 1992, 79-80:
"Vielleicht ist auch, angesichts des noch bescheidenen Charakters ihrer Trigonometrie, eben in dieser Vorstellung einer der Gründe für die fehlende Strenge der perspektivischen Darstellung bei den alten zu suchen."

13 Simon, as in note 12, 1992, 84:
"Die Analyse der visuellen Wahrnehmung war zweifellos noch nicht genügend fortgeschritten, um die Beschreibung des natürlichen Sehens klar von den Verfahrensweisen der perspektivischen Darstellung unterscheiden zu können."

14 Francesca Salvemini, L’occhio e il suo doppio, Rome: Laterza, 1990, p. 62:
"Operando iconograficamente sui significati, infatti, lo studioso riduce costantemente a schema tutto quello che e non dismostrabile per la mancanza di testimonianze concrete."
Salvemini, as in note 14, p. 73:
"La difficoltà di arrivare a conclusioni logiche di questo tipo nello studio dei trattati, anche quando ogni cautela sia stata rispettata, sta nel fatto che le loro proposizioni sono dimostrative, assumono perciò la forma della "quaestio" che e la forma letteraria del teorema matematico, i cui enunciati non sono logistici come nelle contemporanee teorie fisiche. Questa misura della distanza non sarà percio ne fissa, ne arbitraria, ne razionale ne casuale ne oggettiva, ne soggettiva, sarà invece variabile indipendente. Riconoscere questa regola elementare di per se non matematisa lo spazio empirico piu di quanto la perpendicolarita dell'asse ottico non geometrizzi l'immagine visuale."

Ibid., as in note 14, p. 97:
"Il confronto tra il procedimento dell'Alberti e il metodo di Gaurico ci consente di evidenziare l'impossibilità materiale di stabilire un modello tipologico per gli studi prospettici."


"...l'énonciation n'est pas assignable au seul système des pronoms et des indices de position dans l'espace et le temps. L'appareil formel que met en place le paradigme perspectif est l'équivalent de celui de l'énonciation dans la mesure où il assigne au sujet sa place dans un réseau déjà constitué et qui confère un sens à sa visée, en même temps qu'il ouvre la possibilité de quelque chose comme un énoncé en peinture: comme l'écrit Wittgenstein, le mot n'est qu'un point, la proposition est un vecteur doté d'un sens, c'est à dire d'une direction."


31 Ibid.
32 Ibid., p. 54-57, 59, 63-64, 67, 70, 82, 90-92, 110, 114, 152, 155, 243.
33 Ibid., p. 124.
34 Ibid., p. 246.
37 Cf. Lintvelt (1981). With respect to mediaeval literature see: Kuhn (1973) and Green (1982).
38 It is noteworthy that McLuhan’s own interest in the effects of texts grew out of his contact with the new criticism of Leavis and Empson while in Cambridge in the 1930’s. Cf note 27 above.
40 There is actually considerable debate as to exactly when the alphabet was introduced in Greece, or rather when the full effects of the alphabet came into play. Some have claimed that the alphabet was introduced as early as the tenth century B.C.; others have claimed the late seventh century. For a masterful review of these debates see: Eric A. Havelock, Prologue to Greek Literacy, Delivered November 11 and 12, 1970, The University of Cincinnati, 1971. Havelock notes that early uses of the alphabet from the time of Homer onwards were limited to poetic contexts and that it was not until the fifth century that it became important in the context of prose. I am grateful to Dr. Eric McLuhan for this reference.
42 Brisac, 1984, as in note 40 above, p. 78.
43 Ibid., p. 101.
44 Ibid., pp. 84, 99.
45 Ibid., p. 100.
46 Ibid., p. 108.
47 Ibid., p. 92.
48 Ibid., pp. 127-128.
49 Ibid., p. 126.
50 Ibid., p. 127.
51 Ibid., pp. 136, 142.
It bears noting that the same Geoffroi de Villehardouin was one of the early authors of Chronicles, a theme continued by authors such as Joinville, Froissart and Philippe de Commynes. Cf. Grand Larousse Encyclopédique, Paris: Larousse, 1960, tome 3, p. 102.

Abbot Suger, as in note 50 above, p. 91.


Did changes in literature affect art or conversely? It seems likely that a reciprocal influence occurred. Hence the interplay between images in illuminated manuscripts and those on walls and windows probably went both ways.

Authority. Christine de Pizan's Cité des Dames, Ithaca: Cornell University Press, 1991, pl. 2 etc.
78 For another discussion of this theme, see the author's "Narrative Perspective and the Orders of the Church", I Meeting Siena-Toronto, ed. Sandro Forconi, Siena: Edizioni Alsaba, 1993, pp. 123-162. (Proceedings...in April 1991 during the celebration of the 750th Anniversary of the University of Siena).
79 Roman d'Alexandre le Grand.
80 Roman de Thèbes.
81 Roman de Troie.
82 Roman d'Eneas.
85 See: Christopher De Hamel, as in note 76, p. 165: Historia Destructionis Troiae.
87 Lancelot et le chevalier de la charrette.
88 Perceval le Gallois.
89 See: Christopher De Hamel, as in note 76, p. 149. These books were referred to as in the books of Lancelot "si com li livres Lancelot".
90 See: Dictionnaire de Biographie Française, vol. 8, p. 1278-1279.
91 Tristan y Iseult. See: Grand Larousse Encyclopédique, tome 3, p. 599.
92 Christopher De Hamel, as in note 76, p. 146.
93 Christopher De Hamel, as in note 76, p. 150.
94 Chronique de Frédégaire.
95 Chronique de Turpin.
96 Historia Karoli magni et Rotholandi.
97 See: Grand Larousse Encyclopédique, tome 3, p. 102.
98 Chanson de Roland.
99 Christopher De Hamel, as in note 76, p. 145.
100 See: Grand Larousse Encyclopédique, tome 2, p. 849.
101 Roman de Brut.
102 Roman de Rou ou Gestes des Normands.
103 See: Grand Larousse Encyclopédique, tome 9, p. 339.
104 Chanson des Saisnes ou des Saxons.
105 See: Grand Larousse Encyclopédique, tome 2, p. 849.
106 Chanson de Guillaume.
107 Chanson d'Antioche.

Christopher De Hamel, as in note 76, p. 145.

Christopher De Hamel, as in note 76, pp. 144-145: Roman de Toute Chevalerie.

See: Grand Larousse Encyclopédique, tome 4, p. 874.

Roman de la Rose.


Walther von Wartburg, Französisches Etymologisches Wörterbuch, Basel: Helbing und Lichtenhahn, 1952, Bd. 4, p. 440:

"Schon im lt. des 6. jhs. wird historia verwendet um ein bildliches darstellung eines geschehens zu bezeichnen; diese bed. wird im fr. sehr geläufig."

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See: Grand Larousse Encyclopédique, tome 4, p. 874.

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Gudrun Schleusener-Eicholz, *Das Auge im Mittelalter*, Munich: Wilhem Fink Verlag, 1985, Vol. 2, pp. 959 ff. This extraordinary work is an amazing collection of references to vision.

Ibid., vol. 2, p. 962: Bernhard von Clairvaux, *In festivitate omnium sanctorum, sermo 4* (Opera V), p. 357:

"Triplexiter, enim, fratres, in aeterna illa et perfecta beatitudine fruemur Deo, videntes eum in omnibus creaturis, habentes eum in nobis ipsis et, quod his omnibus ineffabiliter iucundius sit atque beatius, ipsam quoque conoscentes in semetipsa Trinitatem et gloriæ illam sine ullo aenigmate mundo cordis oculo contemplantes."

Gudrun Schleusener-Eicholz, as in note 126, p. 1016: Hugo von Sankt Viktor, *De vanitate mundi*, S. 41 [in her translation]:

"Wollen wir das Auge des Geistes zu dem Unsichtbaren erheben, haben wir die Ähnlichkeiten der sichtbaren Dinge gleichsam als Spuren der Erkenntnis (cognitio) zu betrachten".

Gudrun Schleusener-Eicholz, as in note 126 p. 941:

"Videmus nunc per speculum in aenigmate: tunc autem facie ad faciem."

Gudrun Schleusener-Eicholz, as in note 126, p. 863.

Gudrun Schleusener-Eicholz, as in note 126, p. 866.

Gudrun Schleusener-Eicholz, as in note 126, p. 873: Gregorius Illiberatanus, *In cant.*, *PL suppl.*.1, 501:

"Scriptura sacra quasi quoddam speculum mentis opponitur ut interna nostra ipsa videantur."

Gudrun Schleusener-Eicholz, as in note 127, p. 879.

Gudrun Schleusener-Eicholz, as in note 127, p. 874.

Gudrun Schleusener-Eichholz, as in note 127, p. 875.


For another discussion of this treatise see Hieronymus Spettmann, "Das Schriftchen 'De oculo morali' und sein Verfasser", *Archivium Franciscanum Historicum*, Vol. 16, 1923, pp. 309-322.

Paradoxically as persons approached nature in ever more physical terms they also relied increasingly on images such as the *Book of Nature*, the language of which was written in geometry according to Galileo.


S. Battaglia, *Grande Dizionario della lingua italiana*, as in note 125, p. 613:
"istoriare ornare una superficie (una pariete, un muro etc) con la rappresentazione in pittura o scultura di fatti storici, sacri, leggendari, legati fra loro da un nesso narrativo".


This same idea has been expressed slightly differently by: Brian Stock, *The Implications of Literacy*, Princeton: Princeton University Press, 1983, p. 83:

"Together with the growth of literacy, the optics acted as a scientific foundation for a type of representational art which, although medieval in its roots, came to transcend all that medieval art stood for. This was achieved through the use of perspective: it effectively combined classical representation, which was the illustration of a text, with three-dimensionality, a logical development of the emphasis on the visual."

Some sense of the complexity of this interplay between North and South is provided by John Steer and Anthony White, *Atlas of Western Art History*, New York: Facts on File, 1994. This contains many maps showing, for instance, artists’ travels with respect to Gothic manuscript illumination, metalwork and other decorative arts (p.120).

Brisac, 1984, as in note 41 above, p. 23.

Brisac, 1984, as in note 41 above, p. 67.

Gudrun Schleusener-Eicholz, as in note 126, p. 27: Bacon, *Opus maius*, S. 3,159ff.: *De comparatione perspectivae ad sacram sapientiae et mundi utilitates*.


"non est possibile ut literalis sensus sciatur, nisi homo ad sensum habeat haec opera depicta, sed magis figurata corporaliter; et sic sancti et sapientes antiqui usi sunt picturis et figurationibus variis, ut veritas literalis ad oculum pateret et per consequens spiritualis.... Sed nullus posset de huiusmodi corporum figuratione cogitare nec ordinare, nisi optime sciret libros Elementorum Euclidis et Theodosii et Millei et aliorum geometrarum."

Ibid., p. 235. The Latin from Bridges reads:

"O quam ineffabilis luceret pulchritudo sapientiae divinae et abundaret utilitas infinita, sic haec geometricalia, quae continentur in scriptura, figurationibus corporalibus ante nostros oculos ponerentur. Nam sic mundi malitia diluvio gratiae deleta, attoleremur in sublimi cum Noe et filiis et omnibus animabantibus suis locis et ordinibus collocatis....Certa ipsa visio sensibilis esset pulchra, sed pulchrior quando figuram nostrae veritatis videremus praeentraliter, pulcherrima vero quando scripturae intellectum spiritualum et litteralem contemplantes guaderemus visibilibus instrumentis excitati, quod scimus omnia nunc in ecclesia Dei esse completa, quae
ipsa corpora sensibilia nostris oculis exhiberent. Et ideo nihil repto studioso in sapientiae Dei, quam huismodi figurationes geometricas ante oculos exhiberi. Utinam iubeat dominus quod haec fiat."


*Alacenus de mundo*, Abrahamo de Balines interprete, Vatican, Vat. Lat. 4566, 2v: "Non defecerunt mathematici ab eo quod fragi esset theorice scientie astrologia et comprehensione descriptionis rerum totius universi et omnium partium eius.... nisi percessisset ea semita que sectatur sensatum theorice scientie astrologie et necesserunt ab his sermonibus namque sermones isti id est demonstratio super descriptione figurarum et motuum ordinibus veris ex aspectibus et absolutis demonstrationibus construuntur equidem super motu puncti imaginati ad peryferiam fuctororum circulorum et quatenus declaratum est eorum his libris qui inventi et noti sunt apud nos."

*Alacenus de mundo*, as in note 40. For example, on 27v the phrase “Descriptio autem hec est videlicet” is followed by a diagram. cf. 18r, 21r, 33v, 36v.

*Alacenus de mundo*, as in note 40, 1r: "tandem obviam factus est alacenis liber de mundo ubi celestium motuum theorias ab astrologiae traditus ita compendio scribuntur ut summus rerum et remotionum controversie inter Georgium Cremonensem et Iohannum de Monte Regio notem sole clarius sit invenire."


DSB, XIV, p. 1249.

DSB, XI, p. 197.

DSB, XIV, p. 1249.


Ibid., p. 666.

Ibid.

Ibid., p.660.

Ibid., p.404.

DSB, XIV, p. 457.

Siger de Brabant, *Quaestiones in phiscam* (Borgh. 114), ed. B. Bazan, Louvain-Paris, 1974, l. II, q. 5:

"Nam ea quae in geometria probata sunt per principia abstracta, perspectivus applicat ad materialem sensibilem; et item rotunditatem solis, lunae et terrae non probat astrologus per naturam istarum corruptibilium."


DSB, XII, p. 60.

DSB, IX, p. 361.

DSB, III, p. 23-29. Cf. Vatican, Vat. Lat. 2225, where *Campanus Novariensis Theorica motuum planetarum et instrumenta eorum* (fol. 71-87), occurred along with a *Questio utrum proportio velocitatis in motibus sit sicut propositio velocitatis potentiae moventium ad posteriores reliquas* (fol. 89), treatises of Marliani and others.

DSB, V, 364-365.


DSB, XIV, p. 594.

DSB, VI, p. 301.

DSB, III, p. 27.


DSB, XII, p. 400a.

DSB, XIII, p. 400-401.

DSB, X, p. 541.

DSB, XIII, p. 400-401.

DSB, VII, p. 117.


Gemma Reinerus Frisius, *De radio astronomico et geometrico liber in quo multa ea quae ad geographiam, opticam, geometriam et astronomiam utilissimi sunt demonstrantur*, Antwerp: A. Disthemius, 1545.


Orsini, Latino, *Trattato del radio latino...con I commentarii del R. P. M.Egnazio Danti*, Roma: Appresso Marc’Antonio Moretti e Iacomo Brianzi, 1586.

*DSB*, XVI, 1249.

*DSB*, VII, p. 178.


*DSB*, XI, p. 197-198.

The *Indagini storiche artisticho e bibliografiche sulla libreria Visconteo-Sforzesco del Castello di Pavia*, Milan: Libreria Gaetano Brigola, 1875, p. 256 notes a copy *Euclidis geometria cum planispherio Tholomei*.

*DSB*, VI, p. 68-69.

*DSB*, II, p. 133.

*DSB*, VI, p. 544.

*DSB*, XI, p. 31-33.

*DSB*, I, p. 62b.


*DSB*, III, p. 160.

*DSB*, II, p. 435.

*DSB*, III, p. 217.

*Storia della chiesa*, XIII, 405-406: “che chiama dominus experimentorum”.

*DSB*, X, p. 534a.

*DSB*, III, p. 27. According to *DSB*, III, 23-29, Roger Bacon named him one of the four best contemporary mathematicians.”


*DSB*, VI, p. 273.

*DSB*, III, p. 219a.

*DSB*, VII, p. 117-118.

*DSB*, XV, p. 477.

*DSB*, XIV, p. 273.

*DSB*, X, p. 161; XIII, p. 621.


*DSB*, III, p. 559.

*DSB*, XIII, p. 621.

*DSB*, VII, p. 353b.

*DSB*, XIV, p. 594.

*DSB*, XIV, p. 273.

*DSB*, III, p. 23-25.

*DSB*, VI, p. 273.

*DSB*, X, p. 125.
227 Ibid.
228 DSB, IV, p. 164-165.
229 DSB, III, p. 217.
230 DSB, XV, p. 162-163.
231 DSB, VII, p. 118.
232 DSB, XV, p. 154.
234 DSB, VI, p. 301.
235 DSB, VII, p. 118.
236 See, for instance, Vatican, Pal. Lat. 1384 (8o).
238 See, for instance Giulio Mancini, Discorso della pittura, Vatican, Vat. Lat. 8080, 1603, fol. 34rv:
   "la prospettiva venne che rappresenta il sito di cose artificiosi ricolti di boschi con le loro lontananze et diminuzioni in rispetto della vista, ma perché questi hanno regola, che pendono dalla visione et oggetto vito che ne tratta Vitellione et altri."
   Cf. also Accolti (1625).
   "quod totum potest fieri per astrolabium, sive quadrante vel aliud instrumentum certificationis visuum".
240 Gudrun Schleusener-Eicholz, as in note 126, p. 984: Alcher von Clairvaux, De spiritu et anima, PL. 40, 809:
   "Ratio vis est animae supra corporalia, et infra spiritualia collocata: scemnit enim vera a falsis, quod est logicae; virtutes a vitiis, quod est Ethicae; et per experimenta rerum investigat naturales, quod est Physicae. In his vero tribus tota Philosphia consistit. Totam igitur Philosphiam ratio comprehendit."
242 As but one example we might cite: Vat. Lat. 3380, which has a number of writings of Campanus and a section: Compositis instrumentorum ad invenienda vera loca planetarum et alia plura eiusdem generis and refers (71r):
   "in hac parte quinta remanet nostrti intentio inquierere quomodo debent poni orbes celestium corporum et motis eorumnum it ut ea quae apparent nostris aspectibus videantur veritate."
244 Ibid., pp. 410, 414.
245 Ibid., pp. 281-344.
246 Ibid., p. 309.
247 Ibid., p. 295.
248 Ibid., p. 404.
249 Ibid., p. 405.
250 See the author’s Leonardo da Vinci Studies, vol. II.


"Quia ergo tibi, ut totius entis sedulo scrutatori (dum ens intelligibile à primis suis prodiens principii, entibus individuis sensibilius per modum causae, acti mentis coniungeres, et singularum causas singulas indagares) occurit divinarum virtutum influentiam inferioribus rebus corporalibus per virtutes corporales superiores modo mirabili fieri....Corporalium vero influentiarium lumen sensibile, est medium, superioribus corporibus perpetuis substantium solum in potentia ad ubi existentibus, infima corpora (quaec secundum formas et ubi variantur) mirificè assimilans et connectens. Est enim lumen supremarum formarum corporalium diffusio per naturam corporalis formae materiis inferiorum corpororum se applicans, et secum delatas formas divinorum et indivisibilium artificum per modum divisibilium caducis corporibus imprimens, suique cum illis incorporatione novas semper formas specificas aut individuas producens, in quibus resultat per actum luminis divinum artificium tam motorum orbium quàm moventium virtutum."


See Vescovini (1965), as in note 152, p. 244.

Averroes, *Commentary on Aristotle’s Metaphysics* cited in BSB, as in note 43 above, p. 3.

DSB, as in note 43 above, p. 4.

*The Opus Majus of Roger Bacon*, a translation by Robert Belle Burke, Philadelphia: University of Pennslyvania Press, 1928, pp. 180-185:

"Fourth Distinction Chapter XII. Whether the five figures of the regular solids correspond to the world as the Platonic school maintained."

See Doppelmayr, 1730, p. 19. This passage is mentioned in connection with Leonardo in Veltman (1986), pp. 171 and 447, where Doppelmayr’s comments are also reproduced.

See Francesco Maurolyco, *De quinque solidis, quae vulgo regularia dicuntur, quae videlicet eorum locum impleant ut quae non, contra commentatorem Aristotelis Averroem*, Rome, Bibl. Naz. Vittorio Emmanuele, Fonti. Min. S. Pantaleone, P. 117, fol. 20v and 21r re: dating. This same manuscript records five different ways of finding two mean proportionals (Hero, Philo, Pappus, Archimedes and Menacehmus on fol. 42r, plus sections on Euclid’s *Elements*, dated from 1534 to 1541. Another treatment of the regular solids by Maurolyco is found in Paris, Bibliothèque Nationale, Fonds Latin 7463, which has been discussed by J. H. T. Muller, “Zur Geschichte des Dualismus in der Geometrie,” *Grunert’s Archiv der Mathematik und Physik*, Bd. 34, 1860, pp. 1-6. This work of Maurolyco becomes the more interesting that the Benedictine monk later had close

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256 See Vescovini (1965), as in note 152, p. 244.
257 Averroes, *Commentary on Aristotle’s Metaphysics* cited in BSB, as in note 43 above, p. 3.
258 DSB, as in note 43 above, p. 4.
259 *The Opus Majus of Roger Bacon*, a translation by Robert Belle Burke, Philadelphia: University of Pennsylvania Press, 1928, pp. 180-185:
260 See Doppelmayr, 1730, p. 19. This passage is mentioned in connection with Leonardo in Veltman (1986), pp. 171 and 447, where Doppelmayr’s comments are also reproduced.
261 See Francesco Maurolyco, *De quinque solidis, quae vulgo regularia dicuntur, quae videlicet eorum locum impleant ut quae non, contra commentatorem Aristotelis Averroem*, Rome, Bibl. Naz. Vittorio Emmanuele, Fonti. Min. S. Pantaleone, P. 117, fol. 20v and 21r re: dating. This same manuscript records five different ways of finding two mean proportionals (Hero, Philo, Pappus, Archimedes and Menacehmus on fol. 42r, plus sections on Euclid’s *Elements*, dated from 1534 to 1541. Another treatment of the regular solids by Maurolyco is found in Paris, Bibliothèque Nationale, Fonds Latin 7463, which has been discussed by J. H. T. Muller, “Zur Geschichte des Dualismus in der Geometrie,” *Grunert’s Archiv der Mathematik und Physik*, Bd. 34, 1860, pp. 1-6. This work of Maurolyco becomes the more interesting that the Benedictine monk later had close
contacts with the Jesuits responsible for setting up their earliest curricula (see p. 50* of text).

262 Storia della chiesa, as in note 39 vol. XIII, p. 508.
263 Ibid., p. 635.
264 Ibid., p. 638-639.
265 Ibid., p. 643.
266 Ibid., p. 641-643.
269 Vat. Barb. Lat. 304, fol. 202r:
"Quien no suiniere practicado el deseno...para desenar bien se requiesce buenos instrumentos, buenos compasses unos de apuntar y otros de haber con plenna circulos."
270 Ibid, 211r:
"La prospectiva pratica usa de algunas reglas fundadas y sacadas de Geometria y uno de los principios y debe tomar es y la vista se haze per lineas rectas aunque es principio y peneta Vitellion por un instrumento suyo."
271 Ibid., 284r:
"Maurolyci a 8 de octobre 1557 de scien’ emel Mx Jeronymo este problema de Magister Federigo datam connoidis obtusi anguli portionem plano basi equidistanti ita dividere ut partes portionum habeant eandem date proportionum."
272 Ibid., 287r:
"Perspectiva quando se leera se tendra esta orden que se vean estos auctor es Ptolemeo Euclides Alhazen Vitellion el commento de la perspectiva commun de Butii e vean los canones del instrumento de Vitellion y sen los autores e eslem ene cada pacio y Federico perspectiva practica y el modo e tiene el de Urbino y se algumas experientias como seria un pelo sobre e lagna par hazar un poco de concavidad haze una notable sobra abaxo.... perspectivae figureae 83 hoc est perspectivae communis."
273 Monumenta paedagogica, as in note 268, 1901 (Monumenta Historica, S. J.), pp. 84-88:

<table>
<thead>
<tr>
<th>Year 1</th>
<th>[Months]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arithmetica</td>
<td>2</td>
</tr>
<tr>
<td>Geometria</td>
<td>4</td>
</tr>
<tr>
<td>Sphaera</td>
<td>3</td>
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<tr>
<td>Geographia</td>
<td>3</td>
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</table>

<table>
<thead>
<tr>
<th>Year 2</th>
<th>[Months]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theorica planetarum</td>
<td>4</td>
</tr>
<tr>
<td>Astrolabium</td>
<td>3</td>
</tr>
<tr>
<td>Prospectiva</td>
<td>3</td>
</tr>
<tr>
<td>Expositio almanach aut theologia</td>
<td>2</td>
</tr>
<tr>
<td>Los summolistas dos meses de arithmetica</td>
<td></td>
</tr>
</tbody>
</table>
[Year 3]  Los logicos geometria  4
Sphaera  3
Geographia  2
Astrolabium  3

[Year 4]  Los philosophos, teorica de planetas  4
Expositio almanach, aut tabularum  3
Prospectiva  3
De horologis  2

274 Ibid., pp. 89 -97: De studiis societatis P. Hieronymi Natalis (De rat. stud. 1583-1613, f. 1-23):
"Secunda lectio complectitur musicen speculativam et perspectivam. Haec legetur, vel communis vel Vitellionis; illa Fabii Stapulensis, vel alterius, si quis commodior videntur. In hanc lectionem poterit reiici est aliquid dicatur de praxi geometria et mensurationis ex aliquo auctore etc....
Tertia lectio singulis annis versabitur in astrologia, inchoanda theoria planetarum; poterit coniugi super aliquid ex magna constructione Ptolemaei, vel saltem epitome Joannis de Monteregeo, tabulae Alfonsi, astrolabium etc. Haec dispositio faciet ut triennio philosophi audiant principia saltem totius mathematicae ac quotidie singuli audiant tantum unam lectionem. Physici primam, naturales secundam, metaphysici tertiam. Mathematicus vero, nihil possit interpretari astronomiae judiciarie, sed totum ejus negotium speculativis mathematicae."

275 Ibid., p. 477, De studiis mathematicis (Ex cod. Rom. stud. II, fol. 203r autographum P. Hieronymi Torres):
"Y commencando del principio, los dialécticos, tres meses antes del primer año, sería bien que oyessen la arithmética práctica el mes de Agosto y Setiembre y Octubre; y al principio de la lógica oyessen tres libros de Euclides, que se leerán no en menos de 40 meses; y luego oycen la sphera, que duraría otros quatro meses; y la geographía, que duraría otro tres ó quatro meses, y ansi se concluiría el segundo año. El tercero teóricas de planetas por espacio de quatros meses, y el astrolabio de otros quatro, y la perspectiva los otros quatro, y desta manera avria dos lectiones, la una á la mañana la primera hora, y la otra luego después de comer...y que cada uno tuuiesse un compás y una regla, con que exercitassen en hazer algunas figuras: y si se diessen cuatro ó cinco meses despues de acabado el curso, podrían oir el quarto, quinto y sexto y undécimo de Euclides, y dar una passada á las teóricas, y á introducirse en las tablas; y si huuiese tiempo que oyessen algo de reloges, ó el anulo, ó el quadrante, ó el radio, ó el computo ecclesiastico, ó una sphera sólida."

Cf. ibid. p. 478 for a related programme.

276 Another list in Cod. Rom. stud. II, 201-202 cited in: Monumenta paedagogica S. I., as in note 268, p. 476 refers to beginning with Euclid, Theodosius and Apollonius and then continuing with what is effectively a combination of theory and practice:
"Quoniam enim in schola sex iam priores libros audierunt, poterunt a 7o initium audiendi facere ad 12m inclusive; tum vero addere Theodosio spheraica elementa, et
aliqua ex cognitis Apolonii; quod satis commode uno anno fieri posset, si duas
lectiones audirent singulis diebus....
ita ipsa quoque a prandio per horam, eodem tempore, dum docendi finis fiat theoricas
planetarum, gnomonice, astrolobe, aliquid ex Archimede et ex algebra, distribuitis
quasi in orbem materiis audire atque ita instructores ad docendum venire, quod
reliquis etiam studiis et ornamento foret et utilitati."

Christopher Clavius, *Cod. Rom. stud. II*, 350-351r cited in: *Monumenta paedagogica*
S. I., as in note 268, 471-472:
"Modo quo disciplinae mathematicae in scholis societatis possent promoveri....
Cum tamen apud peritos constet physicam sine illis recte percipi non posse,
presertim quod as illam paertem attinet, ubi agitur de numero et motu orbium
celestium, de multitudine intelligentiarum, de affectibus astrorum, qui pendent ex
varis coniunctionibus, oppositionibus et reliquis distantii inter sese, de divisione
quantitatis continuinae in infinitum, de fluxu et reflexu maris, de ventis, de cometicis,
iride, halone et aliis rebus meteorologicis, de proportione motuum, qualitatum,
actionum, passionum, et reactionum etc. de quibus scribunt calculatores."

When Galileo wrote his *Discorso del flusso e reflusso del mare*, (copy in Vatican,
Vat. Barb. Lat. 4271), on 8 January, 1616, he specifically announced that he would
elaborate on these themes in his System of the world: lv "quando piu difusamente
trattero questa materia nel mio Sistema Mondano."


See Aurelio Roncaglia, “La letteratura franco-veneta”, in: *Storia della letteratura
727-159. Brunetto Latini was in France from 1260-1266. Aldobrandini da Siena went to
France in 1287.

II. HISTORY

p. 40, Prologue.

*Filarete’s Treatise on architecture*, tr. J. R. Spencer, New Haven and London: 1965,
p. 305 (Bk. XXIII, fol. 179r).

Vitruvius, *De Architectura libri decem*, ed. C. Fensterbusch, Darmstadt:
Wissenschaftliche Buchgesellschaft, 1976, p. 308:
"quemadmodum oporteat ad aciem oculorum radiorumque extensionem certo loco
centro constituto [ad] lineas ratione naturali respondere, uti de incerta re certae
imagines aedificiorum in scaenarum picturis redderent speciem et, quae in directis
planisque frontibus sint figurata, alia abscedentia, alia prominientia esse videantur."

S. Sulzberger, “Rubens et L’Antiquité”, *Revue belge d'archéologie et d'histoire*,
Antwerp, vol. 1, 1941, pp. 62-63:
"Cela paraît être l'ouvrage d'un bon peintre, mais l'optique n'est pas soigneusement
observée, car les lignes des édifices ne se coupent pas en un point de hauteur égale à
l'horizon, et pour le dire en un mot, toute la perspective est manquée. On trouve de
semblables erreurs dans certains édifices représentés sur les revers des
médailles....Cela me fait conjecturer que malgré les excellents préceptes d'optique,
donnés par Euclide et par d'autres, cette science n'était point alors aussi vulgairement
connue de tous qu'elle l'est aujourd'hui."

286 M. le Comte De Caylus, "De la perspective des anciens", Mémoires de Littérature,
Paris and Amsterdam, tome 22, 12 Août 1749 (1751), p. 320:
"perspective, c'est à dire, le changement et la diminution que l'air pour la couleur et la
distance pour le trait, apportent sur les objets exposés à notre vue."

287 Re: Lessing's views on perspective in Antiquity see: Historisches Wörterbuch der
Philosophie, hrsg. Joachim Ritter, Karlfried Gründer, Basle: Schwabe und Co. AG

288 Graziella Federici-Vesovini, Studi sulla prospettiva medievale, Turin: G. Giapichelli,
1965, p. 267:
"Il privilegiamento del vedere e l'importanza attribuita ai fenomeni luminosi, propri
della tradizione neoplatonico medievale fondata su un ideale del sapere noetico e
contemplativo, si transforma nell'opera di Biagio Pelecani da Parma in un
privilegiamento della conoscenza empirica, sperimentale e quantitativa della natura,
sulla basa di una diversa utilizzazione delle nozioni geometriche dell'ottica antica."

289 Fiocco, 1944, 14:
"Ecco perché la prospettiva, finché fu in atto, fu sempre ben altra cosa della
sistematica, e compagna inseparabile dell’intuizione."

290 Liliane Guerry, “L'évolution de la notion de l'espace”, Art d'aujourd'hui, Paris, vol. 5,
no. 2, 1951, p. 9:
"Exprimer, au moyen d'une surface à deux dimensions, l'espace tridimensionel: tel est
le problème qui se pose au peintre et qu'il devra résoudre par un compromis.
L'histoire de ce compromis, ses hésitations, ses affirmations, ses redites, ses oublis ou
ses négations, c'est l'histoire même de la perspective."

291 Francastel, as in note 7, 1951, 16:
"ils constituent deux engins dont l'intérêt est davantage, dans l'esprit de leur auteur,
de permettre une étude pratique des jeux de la lumière que de réaliser une oeuvre
exemplaire."

292 Francastel, as in note 7, 1951, p. 13:
"conçu non pas comme un bloc massif mais comme le lieu d’intersection des plans
géométriques qui correspondent aux axes des mouvements."

293 Francastel, as in note 7, 1951, 22, 23:
"La découverte de Brunelleschi n’a d’abord paru une révolution que dans le domaine
de la construction.
Le premier artiste qui ait eu la révélation du miracle qui passait à la portée des artistes
est Uccello."

294 Francastel, as in note 7, 1951, 25:
"Cette découverte, ce système, dans la mesure, ou il ne consiste que dans la réduction
du point de vue à la vision monoculaire et dans le choix d’un point de fuite unique
situé dans le fond du tableau, dans la mesure ou celui qui l’utilise ne se soucie pas
l’existence de certaines lois de l’esprit révélatrices d’un nouvel idéal, est d’une
application plus limitée que beaucoup d’autres qui avaient paru vers la fin du XIVe
siècle."

295 Francastel, as in note 7, 1951, p. 28:
"on constatera aisément que, même pour les contemporains, le nouveau système n’a jamais eu l’apparence qu’on lui prête actuellement d’une clef toute simple pour la résolution unitaire et réaliste des problèmes de représentation plastique du monde extérieur sur l’écran plastique à deux dimensions."

Francastel, as in note 7, 1951, p. 29:
"la perspective n’est pas une loi constante de l’esprit humain, mais un moment de l’histoire des idées sur l’espace."

Francastel, as in note 7, 1951, p. 43:
"l’étendue. C’est par une extraordinaire déformation qu’on en est venu à dire et à croire que la projection linéaire de l’espace ramenées à un point de vue unique conduisait à la représentation ouvert."

"une solution technique, comme la perspective linéaire, est génératrice, parmi d’autres procédés d’une organisation différentielle des lieux, une certaine implantation des figures les soustrait à l’espace intérieur de l’image et les situe à l’intersection du champ figuratif et de l’espace du spectateur."

Francastel, as in note 297 above, 1967, p. 256:
"Cependant le passage à Florence d’un ordre magico-analogique à un ordre dialectique du perçu et de l’imaginaire constitue un moment décisif, l’erreur généralement commise étant de l’avoir considéré comme rapprochant les hommes d’une connaissance positive des lois immuables de la nature et non comme la conséquence d’une transformation des conduites mentales d’un certain milieu."

Pierre Francastel, as in note 175, 1967, p. 345:
"La perspective linéaire n’a constitué d’ailleurs, qu’un de ces cadres imaginaire, qu’une des structures justificatives de l’ordre nouveau des significations. Ce n’est pas elle qui a concrétisé la véritable invention, la clé du renouveau de la peinture et de la culture de ce temps. Elle a joué, certes, son rôle; mais elle ne constitue qu’un des moyens auxquels ont eu recours les artistes désireux de prendre part aux spéculations de tous les modernes."

"La prospettiva razionale era divenuta, con Masaccio ed i suoi grandi successori fiorentini, un mezzo superiore e scrupolosamente controllato per organizzare lo spazio, per distribuire le figure, per stabilire gerarchie fra loro. Un leggero abbasamento della linea d’orizzonte esalta la figura; la diminuzione progressiva dei punti di riscontro permette di inserire con metodo utili particolari negli intervalli dei piani anteriori."

Francesca Salvemini, *La visione e il suo doppio. La prospettiva tra arte e scienza*, Rome: Laterza, p. 15:
"La prospettiva non riproduce, così come esprime esteticamente soltanto un fenomeno visivo, essa restituisce e determina la cognizione della veduta di prospetto."

Galileo, cited in Thuillier, 1984, p. 1385:
"L’imitation la plus artistique est celle qui représente la tri-dimensionalité dans son opposé qu’est la surface plane."
Thuillier, 1984, p. 1385:
"une nouvelle manière de regarder le monde, de ‘sentir’ son organisation, d’imaginer ses structures."

Ibid., p. 1388:
"Et que la recherche d’un espace homogène et unifié correspondait certainement à des sociétés ‘avancées.’

Ibid., p. 1391:
"Ce développement des mathématiques pratiques, dans l’Italie des XIVe et XVe siècles, aide à comprendre pourquoi et comment le ‘regard’ porté sur les choses s’est transformé, s’est en quelque sorte ‘géométrisé’. Découvrir des proportions, identifier des triangles, des cones ou des cylindres, c’était désormais une sorte d’‘habitude culturelle’ largement développée."

Thuillier, 1984, p. 1395:
"En ce sens, la topographie, la cartographie, la cartographie et la perspective apparaissent comme les branches d’une science générale de la représentation spatiale."

Thuillier, 1984, p. 1398:
"La perspective linéaire classique malgré son intérêt, ne peut être considérée comme douée d’une valeur absolue. Elle est commode, elle donne une certaine satisfaction à l’intellect; mais d’autres systèmes sont possibles (comme la perspective dite ‘courbe’ ou ‘curvilinéaire’, dont le principe est connu depuis longtemps)."


"Doch gibt es noch tiefere Gründe für das Erlöschen der perspektivischen Darstellung in der Malerei: das Misstrauen an die Durchschaubarkeit der Realität. Nicht das
Interesse an der Realität als solches ist geringer geworden, das Wissen um die Erscheinungen der Aussenwelt ist grösser, als es jemals war - aber der Mensch fühlt sich nicht mehr im Mittelpunkt dieser Aussenwelt, ihre perspektivische Zuordnung zu einem fest auf einem bestimmten Standort stehenden Betrachter ist fragwürdig geworden. Und zwar beides: der Standort wie die Zuordnung. Der Verzicht auf die perspektivische Ordnung der Gegenstände im Bildraum bedeutet ein Fallenlassen des Anspruches, die Umwelt gedanklich zu beherrschen oder auch nur die Würde des Betrachters gegenüber der Umwelt aufrechtzuerhalten, - Der persönliche Betrachter -als Augenpunkt und Horizont des Bildfeldes- wird preisgegeben zugunsten einer persönlichen, anonymen Objektivität. Der Maler glaubt nicht mehr an ein verbindliches Gefuge der Welt, das die äusseren Gegenstände und den Betrachter zugleich umfassen würde, wie der perspektivische Raum beide umfasste."

311 Brion-Guerry, 1950, p. 9:
"Son champ visuel est tout d’abord un espace restreint où l’illusion de la troisième dimension est suggérée par la courbe. Le point de vue, qui n’est pas le lieu de jonction des fuyantes, est mobile. C’est à peu de chose près -nous verrons plus loin que la comparaison n’est pas forcée - la conception spatiale des Grecs. Par un jeu artificiel de combinaisons constructives, Cézanne s’efforce de stabiliser une composition essentiellement mouvante, mais il ne parvient pas à homogéniser le contenu spatial - c’est-à-dire l’objet- et son contenant: l’enveloppe atmosphérique."

312 Brion Guerry, 1950, p. 179:
"Le champ visuel de l’image se trouve donc agrandi de tout ce qui est évoqué sans être dit. L’horizon ne se ferme pas à la limite visible d’une construction perspective, ainsi qu’il adviendrait si, avec cette construction, s’exprimait dans sa plénitude la représentation figurée. L’édifice spatial, si loin qu’on le prolonge dans l’étroitesse d’un schéma constructif préétabli, ne contient pas la totalité expressive de l’image. Celle-ci ne s’accomplit que dans les prolongements dont la comble l’imaginaire du spectateur et qu’il ne doit pas lui refuser, sous peine de mutiler en même temps l’évocation de l’objet. Ainsi le champ spatial s’illimite t-il: plus exactement, il faudrait dire qu’il n’a pour limites que celles-là mêmes de l’objet."

313 Francastel, as in note 7, 1951, p.147:
"Un nouveau système de visualisation s’élabore. Les qualités de l’espace se concrétisent cette fois dans un compartimentage basé non plus sur les échelles différentielles de la veduta- combiant les deux grilles bien tempérées de la perspective linéaire et du foyer unique de la lumière -, mais sur la nouvelle ambiguité spatiale du support- la toile - opposée aux valeurs autonomes de la couleur pure."


317 Ibid., p. 87.

Ibid., p. 292.

Ibid., p. 146.

Ibid., p. 160.

Ibid., p. 336.

Ibid., p. 160.

Ibid., p. 148.

Bicknell, as in note 143, p. 102.


Pavel Florenskij. *La prospettiva rovesciata e altri scritti*, a cura di Nicoletta Misler, Rome: Casa del libro editrice, 1983, p. 73:

"La vivacità della discussione mi confermo ancora una volta che il problema dello spazio è uno dei fondamentali in arte e, dico di più, in una concezione del mondo in generale. Ma questo problema: lo spazio nell'arte figurativa, nel presente articolo non e esaminato e costituisce l'oggetto delle mie lezioni di analisi della prospettiva, in preparazione per la stampa, tenute negli anni 1921-1923...."


"Andererseits ist auch eine entgegengesetzte Betrachtungsweise möglich, die man bedingt mit der Methode des Dechiffrierens vergleichen könnte. Bei dieser zweiten Art erwächst einem die Aufgabe, das spezifische System der Darstellungsweise in der alten Malerei zu rekonstruieren, das heisst die besondere Sprache zu entziffern, die der alte Meister beherrschte und die offensichtlich auch dem zeitgenössischen Betrachter verständlich war."

Ibid., p. 10:

"Setzt man die Analogie mit der Sprache fort, dann ist es angebracht, die Bedingtheit eines beliebigen Perspektive-Systems hier mit dem konventionellen Charakter einer beliebigen Sprache zu vergleichen, die für die Übermittlung eines bestimmten Inhalts verwendet wird. Tatsächlich gibt es Grund in der Annahme, das das System der linearen Perspektive gegenüber andere Systemen nicht a priori in jeder Hinsicht als natürlicher für den Menschen angesehen werden kann."

Alexandre Savérien, *Histoire des progrès de l'esprit humain dans les sciences exactes*, Paris: Chez Lacombe, 1766, p. aiijr:

"Je ne crois pas qu’on puisse trouver dans un Livre, plus de vérités qu’en contient cette Histoire."

Savérien, 1766, 254:

"construisit une machine avec laquelle il trouva la trace des rayons de lumiere."

Ibid., p. 254:
"Il imagina aussi des points qu’on appelle Points de distance, sur lesquels tombe une ligne qui fait, avec le tableau, un angle de quarante-cinq degrés, de façon que leur éloignement sur la ligne horizontale tirée sur le tableau, est égale à la distance de l’œil au tableau. Par-là il découvrit que toutes les lignes horizontales faisant, avec le tableau, un angle de quarante-cinq degrés, ont pour images des lignes qui passent par les points de distance."

S. Serlio, as in note 5, p. 18v:

"Bramante suscitatore della bene accompagnata Architettura, non fu egli prima pittore & molto intendeute nella prospettiva prima che si desse adessa arte? Il divino Rafaello da Urbino non era universalissimo pittore, e molto instrutto nella prospettiva prima che operasse nell'architettura? Il consumatissimo Baldeser Peruzzi Sanese fu ancor lui pittore, e nella prospettiva tanto dotto che volendo intendere alcune misure di colonne, & d' altre cose antiche per tirarle fin prospettiva, si accese talmente di quelle proporsizion & misure, che alla Architettura al tutto si diede, nella quale andò tanto avanti, che a niuno altro fu secondo. Lo intendente Girolamo Genga, non fu ancora lui pittor excelfente & nella prospettiva espertissimo, come ne han fatto fede le belle scene da lui fatte per compiacere al suo padrone Francesco Maria Duca di Urbino, sotto l'ombra del quale è divenuto ottimo Architetto? Iulio Romano vero allievo del divin Raffaello si nella prospettiva, come nella pittura per mezzo di quelle arti non s'egli fatto buonissimo Architetto?"

Daniele Barbaro, *La pratica della perspettiva*, Venice: Borgominieri, 1568, Proemio:

"Ma in che modo, & con quali precetti si regessero, niuno (che io sappia) ne gli scritti suoi a lasciato memoria. Se forse non vogliamo chiamare precetti, & regole, alcune pratiche leggeri poste senza ordine, & fondamento, & explicitare rozzamente: perche di queste ne sono pure alcune di Pietro dal Borgo S. Stefano, e d'altri, che per gli idioti ci potriano servire. Poche cose ci ha lasciato Alberto Durero, benche ingeniose & sottili. Piu grossamente si è portato il Serlio: ma l'uno & l'altro (dirò così) si sono fermati sopra il limitare della porta....Federico Commandino nella sfera di Tolomeo ha posto alcune dotte demostrazioni, come egli è solito sempre di fare, pertinenti alla prospettiva, come principij di quella, non inutili per eccitare gli animi de gli studiosi: Ma quanto allo essercitio, & alla introduttione di persone nove all'operare di mano oscure, e difficili."

### III. VISION AND REPRESENTATION

337 Ibid., p. 27.

"Ce facteur, c'est le sentiment que nous avons, que les astres à l'horizon, notamment la lune, sont des objets terrestres."
402

"En effet, le dessin linéaire, même correct quant à la perspective, peut difficilement passer pour une manifestation du réalisme visuel....Bref, le dessin a le caractère intellectuel d'un schéma plutôt que le caractère sensible d'une copie."

341 R. Blanché, 1946, as in note 339 above, p. 160:
"Notre système n'a donc pas cette universalité et cette nécessité que nous étions tentés de lui prêter."

342 R. Blanché, 1946, as in note 339 above, p. 179:
"Il ne s'agit pas tant, pour l'artiste, de peindre ce qu'il voit, que d'arriver à voir quelque chose qui puisse se peindre, et qui soit en même temps digne d'être peint; de se faire, en d'autres termes, une réalité visuelle qui soit à la fois délectable pour le regard et transposable sur la toile."


**IV. APPLICATIONS: TECHNICAL**

344 Wilhelm Shickhardt, *Lichtkügel*, 1624:
"Sag ich, dass alle, auch die gerädesten Linien, so nit directe contra pupillam stracks vor dem Aug stehen, oder durch sein Ax gehn, nothwendig umb etwas gebogen erscheinen. Das glaubt gleichwohl kein Mahler, darumb mahlen sie die gerade Seiten eines Gebäws mit geraden Linien, wiewohl es nach der wahren Perspectifikunst eigentlich zu reden nit recht icht...Das Nüsslein beisset auf Ihr Künstler". Cited by Hansen, 1973, p. 147.

"L'œil étant une portion de sphère dont le centre est le point visuel, la pinnule, tous les objets viennent se reproduire sur une surface courbe."

"Daraus folgt unabweisbar, dass es einzig und allein auf einer solchen Kugeloberfläche möglich ist, alle diese Längenmasse, das heisst alle perspektivischen Dimensionen in ihrem richtigen Grösse graphisch darzustellen".

347 Miloutine Borissavlievitch, "Perspective 'optique' ou perspective 'sphérique'", *La construction moderne*, Paris, Juillet 1953, p. 245:
"La perspective optico-physiologique n'est pas une perspective sphérique et si elle se sert, elle aussi, de cercles horizontaux et verticaux, ce n'est qu'en le considérant comme de simples périmètres dont le but est de déterminer les rapports entre les grandeurs spatiales exprimées au moyen d'angles visuels, et non de regarder les images projetées sur ces arcs et sur une sphère."

"Verifica dei limiti della prospettiva tradizionale, tentando di rappresentare, in un'unico disegno prospettico, il soggetto che guarda e lo spazio come e visto dal soggetto stesso."

For a basic description of the difference between vector and raster graphics see: William G. Mitchell, *The Re-Configured Eye*, as in note 208, pp. 4-6.

V. APPLICATIONS: METAPHORICAL


355 *Nuovi canti carnacialeschi del rinascimento*, ed. C. S. Singleton, Modena, 1940, p.18: "Se la ricchezza, sapienza e fede, di fuor falsa il colore, dunque, chi al vestir di costor crede, fa più degli altri errore; perché la lingua, l'intelletto e'l cuore hanno pien di dispetti, e l'esser puri e netti vi danno indizio; e questo sol deriva che'l mondo è tutto fatto in prospettiva."


357 Böckmann, 1973, p. 61: "Was also ist die Perspektive des Dichters? Sie besteht darin, dass er die Zeitfolge, in welcher seine Nachahmung fortschreitet, dann und wann unterbricht, und in andere Zeitfolgen übergeht, in welchen sich die Gegenstände, die er schildern will, ehedem befunden, bis er den Faden seiner eigenen Zeitfolge wieder ergreift."


"Das scheint uns das Eigene und neue im Erzählen der Cervantes, Fielding und Wieland zu sein: dass ein durchgehend persönlicher Erzähler als Vermittler hervortritt, der von sehr vielseitigem Wesen ist; dass das Erzählte in mehrere Perspektive gerückt und die Sprache damit untergründig wird; dass der Leser einbezogen wird und damit die Aufmerksamkeit dabei sein muss, um das Untergründige zu erfassen, dass es aber bei allen Überraschungen, die sich der Erzähler mit ihm erlaubt, zuletzt in dem Glauben an die "Natur" eine Gemeinsamkeit des deutens und nachsichtigen Wertens zwischen beiden gibt."

360 Kayser, 1968, p. 33:
"als sei die Undurchsichtigkeit der Welt so stark und die Frage nach sinngehalten so unlösbar, dass es unmöglich sei von einem entfernteren Standpunkt aus (eben dem des epischen Erzählers) als Überblick zu gewinnen, in sich geschlossenes Geschehen wahrzunehmen, zentralen Sinnsbezug aufzudecken und überhaupt schon die Sicherheit einer betrachtenden Haltung zu gewinnen."

361 Lieselotte E. Kurth-Voigt, Perspectives and points of view, Baltimore: Johns Hopkins University Press, 1974, p. 44.


363 José Ortega y Gasset, La deshumanización del arte, Madrid: Revista de Occidente, 1070, p. 51:
"Si ahora, en vez de dejarnos ir en esta dirección del propósito, lo invertimos y, volviéndonos de espaldas a la presunta realidad, tomamos las ideas según son- meros esquemas subjetivos- y las hacemos vivir como tales, con su perfil anguloso, enteco, pero transparente y puro- en suma, si nos proponemos deliberadamente realizar las ideas-, habremos deshumanizado, desrealizado estas. Porque ellas son, en efecto, irrealidad. Tomarlas como realidad es idealizar- falsificar ingenuamente. Hacerlas viver en su irrealidad misma es, digámoslo así, realizar lo irreal en cuanto irreal. Aquí no vamos de la mente al mundo, sino al revés, damos plasticidad, objetivamos, mundificamos los esquemas, lo interno y sujeto."

364 G. Lukacs, "Das Problem der Perspektive", in: Porotokoll des Iv. Deutschen Schriftstellerkongresses, 1956, p. 77:
"erstens ist etwas als Perspektive dadurch bestimmt, dass es noch nicht existierend ist. Würde es existieren, wäre es nicht Perspektive für die Welt, die wir gestalten; zweitens; diese Perspektive ist aber nicht eine bloße Utopie..., sondern...die notwendige Konsequenz einer objektiven gesellschaftlichen Entwicklung, die sich dichterisch in der entfaltung einer Reihe von Charakteren in bestimmten Situationen objektiv äussert, und drittens: ist sie objectiv, aber nicht fatalistisch...;es ist... die Tendenz in der Wirklichkeit zur Verwirklichung ... durch taten und durch Handlungen."


Monique Nathan, "Visualisation et vision chez Virginia Woolf," *La revue des lettres modernes*, Paris, V, 1958, p. 271: "Refusant tout commentaire interprétatif, il [the novel] ne doit pas donner à penser, mais à voir. Il découvre la réalité à la vitesse du regard, il multiplie les points de vue, il fait varier les apparences, il dévoile ce que personne ne voit, le dessous et le dessus, l'horizontal et le vertical, le dedans et le dehors, le lointain comme étant près, le proche comme étant loin; il accroit en un mot de toutes les variations d'incidence et de distance le champ visuel limité de l'homme et, ce faisant, accroit sa connaissance du réel."


Beliebiges (an ‘Relatives’), sondern ein diskursives Prinzip der Sinnkonstitution, das wir als relationale Reflexion bezeichnen. Der Sinn, um den es uns hier geht, ist der von Literatur und Geschichte als Literaturgeschichte. So ergibt sich als Antwort auf unsere Fragen die kürzeste Formel: Literaturgeschichte ist Beziehungsinn.”


“Si on est trop jeune, on ne juge pas bien; trop vieil, de même...Ainsi les tableaux vus de trop loin - et de trop près; et il ny a qu’un point indivisible qui soit le véritable lieu; les autres sont trop près, trop loin, trop haut ou trop bas. La perspective l’assigne dans l’art de la peinture; mais dans la vérité et dans la morale, qui l’assignera?”


“Les hommes et leurs affaires ont leur point de perspective: il y en a qu’il faut voir de près, pour en bien juger; et d’autres dont on ne juge jamais si bien que quand on en est éloigné.”


“Comme on doit garder des distances pour voir les objets, il en faut garder aussi pour la société: chacun a son point de vue, d’ou il veut être regardé; on a raison, le plus souvent, de ne vouloir pas être éclairé de trop près, et il n’y a presque point d’homme qui veuille, en toutes choses, se laisser voir tel qu’il est.”


“C’est comme dans ces inventions de perspective, où certains beaux dessins ne paraissent que confusion, jusqu’à ce qu’on rapporte à leur vrai point de vue, ou qu’on les regarde par le moyen d’un certain verre ou miroir. C’est en les placant et s’en servant comme il faut, qu’on les fait devenir l’ornement d’un cabinet. Ainsi les déformités apparentes de nos petits mondes se réunissent en beautés dans le grand, et n’ont rien qui s’oppose à l’unité d’un principe universel infiniment parfait.”

Leibniz, *Essais de Théodicée*, no. 357, in: *Die philosophischen Schriften*, VI, 327:

“Les projections de perspective qui reviennent dans le cercle aux sections coniques, font voir qu’un même cercle peut être représenté par une ellipse, par une parabole, et par une hyperbole, et même par un autre cercle et par une ligne droite et par un pointe. Aussi faut-il avouer que chaque âme se représente l’univers suivant son point de vue, et par un rapport qui lui est propre; mais une parfaite harmonie y subsiste toujours.”

“Et comme une même ville regardée de différents cotés paraît tout autre et est comme multipliée perspectivement, il arrive de même que, par la multitude infinie des substances simples, il y a comme autant de différents univers, qui ne sont pourtant que les perspectives d’un seul selon les différents points de vue de chaque monade.”


"Der Sehe-Punkt ist der innerliche und äusserliche Zustand eines Zuschauers, in so ferne daraus eine gewisse und besondere Art, ide vorkommenden Dinge anzuschauen und betrachten, flüsset. Ein Begriff, der mit der allerwichtigsten in der gantzen Philosophie im gelichen Paare gehet, den man aber noch zur Zeit zu Nutzen anzuwenden noch nicht gewohnt ist, ausser dass herr von Leibnitz hie und da denselben selbst in der Metaphysik und Psychologie gebraucht hat. In der historischen Erkenntnis aber kommt fast alles darauf an."

The significance of this passage fot dt evelopment of historical method has been anaysed in: *Allgemeinen Geschichtswissenschaft* (1752) ed. Reiner Koselleck (1985), pp. 100 ff.

"dass die Menschen einander nicht gnugsam verstehen."

Christian August Crusius, as in note 381above, p. 399:
"Wenn die Menschen einander solche Begriffe mitteilen wollen; so ist das unvermeidlich, dass nicht ein iedweder wegen der Begriffe, welche ihm schon zuvor geläufig sind, und wegen der unterschiedenen Richtung seiner Aufmerksamkeit die Sache gewisser massen mit andern Augen ansehen und so zu reden aus einen anderen Sehe-Punkt betrachten."
"aus der Vergleichung aller Umstände gleichsam den rechten Sehe-Punkt zu bestimmen, aus welchem der Verfasser eien Sache angesehen hat, und sich in den Gedanken in denselbigen zu stellen."


"Unter dem sensus communis aber muss man die Idee eines gemeinschaftlichen Sinnes, d.i. eines Beurteilungsvermögens verstehen, welches in seiner Reflexion auf die Vorstellungswelt jedes anderen in Gedanken (a priori) Rücksicht nimmt, um gleichsam an die gesamte Menschenvernunft sein Urteil zu halten, und dadurch der Illusion zu entgehen, die aus subjektiven Privatbedingungen, welche leich t f"r objetiv gehalten werden könnten, auf das Urteil nachteiligen Einfluss haben würde. Dieses geschieht nun dadurch, dass man sein Urteil an anderer, nicht sowohl wirkliche, als vielmehr blos mögliche Urteile hält, und sich in die Stelle jedes anderen versetzt, indem man blos von den Beschränkungen, die unserer eigenen Beurteilung zufälliger Weise anhängen, abstrahirt:"  


395 Theodor Litt, Ethik der Neuzeit, Munich:.R. Oldenbourg, 1926, p. 94. (Handbuch der Philosophie):

"Wenn Herder den berühmten Satz ausspricht, jede Nation habe den Mittelpunkt ihrer Glückseligkeit - und diese fällt für den Jünger Schaftsburys und Leibnizens mit der Sittlichkeit zusammen- in sich, wie jede Kugel ihren Schwerpunkt, so erfüllt sich in ihm dasjenige, was im Leibniz' Gedanken von dem Perspektivismus des monadischen Weltbildes angelegt war, ohne im Rahmen seines Systems zur Entwicklung kommen zu können."

396 Gustav Teichmüller, Die wirkliche und scheinbare Welt, Breslau: Wilhelm Koebner, 1882, p. 185:

"Wenn wir nun auf der Sonne ständen, so wäre die Kopernikanische Weltauffassung für uns durch den Schein gegeben; da wir auf der Erde stehen, so ist der Schein für die Ptolomäische Lehre; ständen wir auf der Venus oder dem Jupiter, so würden wir jedesmal eine verschiedene perspektvische Auffassung der Welt gewinnen. Die Maus jammert, wenn sie von der Katze ergriffen wird; die Katze aber ist darüber befriedigt. Wenn die Fortschrittspartei ein Gesetz lobt, so sind die Conservativen niedergeschlagen, und umgekehrt.Kurz die Auffassung der Dinge wird hier immer auf einen bestimmten Standpunkt bezogen und ist also perspektivisch. Nun wissen wir, dass unsere Meinungen, Auffassungen oder Begriffe nicht die wirklichen Dinge selbst sind, sondern dass die Wirklichkeit sich zunächst nur in den Elementen der Sinnlichkeit, d.h. in den sogenannten Empfindungen, andeutet, indem den wirklichen Dingen oder Ereignissen entsprechend etwas in uns ausgelöst wird. Alle Meinungen oder Auffassungen von wirklichen Dingen sind also nur Hypothesen zur Erklärung unserer eigenen Zustände. Mithin kann der Begriff des Perspektivischen nicht mehr darin gesetzt werden, dass wir die Beziehung der wirklichen Dinge als des Objects zu dem Gesichtspunkte des Subjects auffassen, weil
die wirklichen Dinge nicht eher für uns da sind, bis wir sie zum Zwecke einer Erklärung unserer Empfindungen schon hypothetisch gesetzt haben. Es bleibt uns vielmehr nur übrig, die Vielheit der Empfindungen selbst als das Object zu nehmen und ihre Zusammenfassung durch das Subject für das perspektivische Bild zu erklären. Diese feinere Definition des perspektivischen wird keine Einwendung erfahren, da uns ja gerade eine solche Zusammenfassung unserer Empfindungen die Auffassung und Anschauung der sogenannten wirklichen Welt liefert, welche doch von allen wissenschaftlichen Forschern nur für ein perspektivisches Weltbild gehalten wird.

397 Ibid, p. 346:
“Wir stellen deshalb den Idealismus mit dem Materialismus und Spinozismus in eine Reihe und erklären alle diese Weltanschauungen für perspectivisch, weil sie uns in das Weltbild, wie es uns von unserem Standpunkte so oder so erscheint, aufgehen lassen.”

398 Nietzsche, Werke, II, 177, 599:

399 Nietzsche, Werke, II, 249-250:
“Wie weit der perspektivische Charakter des Daseins reicht oder gar ob es irgendeinen anderen Charakter noch hat, ob nicht ein Dasein ohne Auslegung oder ohne Sinn eben zum Unsinn wird, ob, andererseits, nicht alles Dasein essentiell ein auslegendes Dasein ist- das kann, wie billig, auch durch die fleissigste und peinlich-gewissenhafteste Analysis und Selbstprüfung des Intellekts nicht ausgemacht werden: da der menschliche Intellekt bei dieser Analysis nicht umhin kann, sich selbst unter seinen perspektivischen Formen zu seh’n und nur in ihnen zu sehen.”

400 Nietzsche, Aug-Sept.1885, Werke, VII/3, 1974, 370ff:
"Kurz wir gewinnen eine Schätzung auch für das Nichtwissen, das Im-Groben- und Groben-Sehen, das Vereinfachen und Fälschen, das Perspektivische".

401 Nietzsche, Werke, Berlin: De Gruyter, 1967, II, 56:
“Das Perspektivische, die Grundbedingung alles Lebens”.

"Soweit überhaupt das Wort 'Erkenntnis' Sinn hat, ist die Welt erkennbar; aber sie ist anders deutbar, sie hat keinen Sinn hinter sich, sondern unzählige Sinne 'Perspektivismus'."


403 Nietzsche, Werke, Bd. II, 861:
“Es gibt nur ein perspektivisches Sehen, nur ein perspektivisches Erkennen; und je mehr Affekte wir über eine Sache zur Worte kommen lassen, je mehr Augen wir uns
für dieselbe Sache einzusetzen wissen, um so vollständiger wird unser Begriff dieser Sache, unsre Objektivität sein."

Nietzsche, "Nachgelassene Fragmente, Frühjahr 1888", Werke, Bd. VIII/3, 1972, p. 165:
"Es ist die 'Perspektiven-setzende Kraft', vermöge deren, 'jedes Kraftzentrum- und nicht nur den Mensch von sich aus die ganze übrige Welt construirt.'

Nietzsche, Werke, III, 903:
"Der Perspektivismus ist nur eine komplexe Form der Spezifizität. Meine Vorstellung ist, dass jeder spezifische Körper danach strebt, über den ganzen raum Herr zu werden und seine Kraft auszudehnen (seine Wille zur Macht)."

Theodor Litt, Ethik der Neuzeit, Munich: R. Oldenbourg, 1926, p. 171. (Handbuch der Philosophie):
"Jener Perspektivismus der Weltbetrachtung und Lebensnormierung, in dem Nietzsche die sublimste Ausserung des Machtriebes aufgedeckt zu haben glaubt, schliesst die idealen Grundprinzipien der Erkenntnis und der Gestaltung nicht aus, sondern ein- wäre es anders, so wäre er nicht Schau und willengeleitete Gestaltung, sondern blindes Losgehen, das sich zu Unrecht den Titels eines geistigen Tuns anmasst."

N. Hartmann, Zur Methode der Philosophie-Geschichte, 1909, p.: bedarf "alles faktische erst der Gesichtspunkte"

Chr. P. Gehler, Das Erscheinungsbild, Grimma: Otto Lorenz, 1912:

Gehler, 1912, 178 (citing Schultze):
1. 'der Raum wie er jedermann von uns erscheint.' 2. 'die uns allen sich darstellende kontinuierliche Ausdehnung, die nach allen Seiten hin in den drei Dimensionen der Höhe, Breite und Tiefe sich erstreckt.' 3. 'der Raum, den notwendig jeder Mensch vorstellt'. 4. 'ein dreidimensionaler Raum, welcher in jedem Individuum seinen Mittelpunkt findet und sich von da für dasselbe ins unendliche ausdehnt.' 5. 'ein individuell bestimmter Raum, der von jedem einzelnen Subjekt und dessen Anschauung abhängig ist'. 6. 'der Raum, den jeder Mensch in Wahrheit perspektivisch sieht.' 7. 'unserer tatsächlicher Augenschein, den wir durch unser sich auf Erfahrung stützendes Urteil verbessern.' 8. 'die durch Urteil ermittelte Raumvorstellung, die erst durch Erfahrung und Reflexion zu stande kommt.' 9. 'meine verbesserte Anschauung.' 10. 'der Raum der sich perspektivisch darstellt.' 11. 'der völlig subjektive, nach dem Standpunkt des anschauenden Individuums sich bestimmende Raum.' 12. 'unsre Sinneswahrnehmung, deren Fehler wir durch die Erfahrung und das sich darauf stützende Urteil in Gedanken verbessern und ausgleichen.' 13. die in Gedanken verbesserte subjektive Raumvorstellung'. 14. 'unser Raumsehen, in dem unser Urteilen fortgesetzt und unbewusst tätig und
‘die Gesamtheit der Raumanschauungen wie sie jeder Mensch von Natur besitzt, die durchaus individuell und subjektiv gefärbt sind.’"

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<tr>
<th>Art des Nexus</th>
<th>Ursache</th>
<th>Wirkung</th>
<th>Name des Nexus</th>
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<td>Durchaus</td>
<td>Zwei Wirklichkeitsobjekte</td>
<td>Ein Wirklichkeitsobjekt oder Durchaus vermuteter Kausalnexus</td>
<td>Kausalnexus in Opposition der Zustand eines solchen</td>
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<td>Kausalnexus</td>
<td>Perspektivikers</td>
<td>der Standpunkt in Opposition.</td>
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Teils objectiver

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<th>Psychophysisch-teils subjektiver Kausalnexus</th>
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<td>Kausalnexus</td>
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<td>Kausalnexus</td>
<td>5. Unsre Realität. Unsre Idealität Kausalnexus der und die Vernunft Vernunft. in Opposition</td>
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Vaihinger, *Die Philosophie als Ob*, 1911, p.: Fiktionalismus.... Jede Fiktion auch eine Sehen der Dinge beinhaltet 'als ob sie so waren'."


Ortega Y Gasset, as in note 408, p. 15.


Ortega Y Gasset, as in note 405, p. 105 ff.

Ortega Y Gasset, as in note 405, p. 106.


Ibid.


‘Das Konstitutiv-Perspektivische in bestimmten Erkenntnissen. Der zweite Punkt wird sein, zur Kenntnis zu nehmen, dass es in bestimmten Gebieten des historisch-geellschaftlichen Erkenntnis kein Makel für einen Wissensgehalt ist, seinen Standort konstitutiv in sich zu enthalten, sondern dass in diesen Gebieten die möglichen Sichten konstitutiv-perspektivische sind und das Problem nicht darin besteht, diese Perspektivität zu vertuschen und zu entschuldigen, sondern sich zu fragen, wie im Elemente dieser Perspektivität Erkenntnis und Objektivität möglich ist. Bei dem visuellen Bilde eines Raumgegenstandes ist ja ebensowenig eine Fehlerquelle, dass der Raumgegenstand wesensmässig nur perspektivisch gegeben sein kann, und das
Probelm besteht nicht darin, wie man ein unperspektivisches Bild zustande bringen könnte, sondern wie man vielmehr durch das Gegeneinanderhalten der verschiedenen Sichten des Perspektivische als solches zu sehen bekommt und damit eine neuartige Objektivität erreichen könnte. So muss auch hier das falsche Ideal der konstitutiv-menschlichen, aber stets sich erweiternden menschlichen Sicht ersetzt werden.”

Mannheim, as in note 391, 1978, p. 257-258:
“Dann muss die dazugehörige Erkenntnistheorie in dem Sinne einer Revision unterzogen werden, dass man die These von der wesensmässig relationalen Struktur des menschlichen Erkennens aufstellt (wie man etwa die wesensmässige Perspektivität der visuellen Gegenstände ohne weiteres zugeben wird.”

Mannheim, 1978, 259:
“...dass gerade in der Entdeckung der Seinsverbundenheit der vorhandenen Einsichten ein erster Schritt zur Lösung gesehen wird. Indem ich den Sichtindex zu einer sich als absolut nehmenden Sicht hinzufüge, neutralisiere ich in einem bestimmten Sinne schon die Sichtpartikularität.”

Karl Mannheim, Wissenssoziologie, hrsg. K. H. Wolff, 1964, p. 357:
"Die Landschaft als Landschaft- dies ist das Beispiel, an dem der Perspektivismus am klarsten exemplifizierbar ist -kann sich für ein menschliches Bewusstsein nur perspektivisch konstituieren, und dennoch löst sich die Landschaft nicht in die verschiedenen von ihr möglichen Bilder auf, weil ein jedes dieser Bilder sich an etwas orientiert (weshalb nicht ein jedes willkürlich Bild möglich ist) und weil die eine Perspektive sofern sie richtig ist, auch von den anderen aus kontrollierbar ist.”

Karl Mannheim, Wissenssoziologie, hrsg. K. H. Wolff, 1964, p. 356:

Spranger, “Der Sinn der Voraussetzungslösigkeit....”, 1929, p. 13:
“1. Die Geisteswissenschaften sind gebunden an den geistigen Gehalt und die geistige Gestalt der besonderen historischen Zeitlage, aus der sie erwachsen.”

Ibid., p. 15:
“2. Alles geisteswissenschaftliche Verstehen ist gebunden an die geistige Weite (Kapazität) und Reife (Geisterfülltheit) der Forscherpersönlichkeit.”

Ibid., p. 16:
“3. Alles Verstehen kommt unbewusst oder bewusst aus einer weltanschaulichen Grundhaltung heraus, und nur vermöge dieser Herkunft kann es Basis werden für letzte Wertsetzungen”.

The term, perspective, does not, for example, occur in the Index of English expressions in the above mentioned translation by Macquarrie and Robinson. For a discussion of the problem see the chapter "Die Krisis der Perspektivität in Heideggers 'Sein und Zeit'", in Gottfried Boehm, *Studien zur Perspektivität*, Heidelberg: Carl Winter, 1969.


Merleau-Ponty, as in note 411 above, p. 403: "de me glisser dans le monde entier."

Merleau-Ponty, as in note 411 above, p. 403: "La chose et le monde n'existent que vécus par moi ou par des sujets tels que moi, puisqu'ils sont l'enchaînement de nos perspectives, mais ils transcendent toutes les perspectives parce que cet enchaînement est temporel et inachevé."

Merleau-Ponty, as in note 411 above, p. 403: "Quand je regarde l'horizon, il ne me fait pas penser à cet autre paysage que je verrais si j'y étais, celui-ci à un troisième paysage et ainsi de suite, je ne me représente rien, mais tous les paysages sont déjà là dans l'enchaînement concordant et l'infinité ouverte de leurs perspectives."


Wenn ich nun in dieser Weise schon von dem wirklichen Haben eines anderen Subjektes, eine mögliche Vorstellung davon gewinne, so ist damit vorgezeichnet, wie diese Vorstellung sich ausweisen müsste, wie ein anderes Subjekt gegeben sein könnte. Das äusserlich veregenwärtigend erscheinende Ich ist äusserlich gegeben, wenn ich einen Körper sehe, der durch seine Ähnlichkeit mit dem meinen die Apperzeption als fremdes Ich fordert, d. i. als ein Ich wie ich. Und das sagt die Apperzeption ist genau eine solche, wie wenn ich im Sinn jener widersprechenden und einstimmig gemachten Vorstellung nicht eine blosse äussere Leiberscheinung habe, sondern eine solche, die auf eine Innenerzeichenung zurückweist, auf eine gleiche, die ich haben würde, wenn ich mich dorthin bewegte, oder wenn ich dort wäre."


Nullpunkt des Koordinatensystems, von dem aus alle Dinge der Welt, die schon erkannten und nicht
erkannten, betrachtet, ordnet und erkennt."

"Soll die Welt eine sein, an sich gegenüber allen subjektiven Erscheinungen, und soll
es also möglich
sein, objektiv gültige Wahrheiten auszusprechen, die nicht mehr in den Relativismus
der Subjektivität
hineinzogen weden können, die jeder Vernünftige notwendig anerkennen muss, so
muss es
Bestände von Digsbestimmungen geben, die jedem Subjekt in gleicher Weise
zugänglich sind und
dabei allen Subjektbeziehung frei sind, die, wenn einem Subjekt zugehörig, es allen
sind."

438 Gottfried Boehm, Studien zur Perspektivität, Heidelberg: Carl Winter, 1969, p. 129:
"Perspektivische Anschauung 'vergeht an der Unendlichkeit des Raumes, was sich in
horizontaften 'Verschwimmen' und im Weitergehen von Horizont anzeigt. Zugleich
aber gewinnt sie in der zentralperspektivischen Konstruktion ein Vehikel ihrer
Verwirklichung, wobei der Augenpunkt als konstruktives Gebilde den Raum regelt.
Die ontologische Valenz des Augenpunktes geht über das bloße Punktsein hinaus,
greift virtuell auf das Ganze seiner 'Welt' über. Die Leere des Raumes wird damit
real, da sie vom Begriffe der punktuell gesammelten Kraft als Feld der
Kraftäusserung erschlossen ist, real wird ebenfalls 'das Widerständliche, welches
durch der unbeschränkten Kompositionsfähigkeit wegen als Atom bestimmt wurde.'

Cf. Paul Graf Yorck von Wartenburg, Bewusstseinseinsstellung und Geschichte,
Tübingen, 1956, p. 146.

439 Georg Lukacs, "Das Problem der Perspektive" in: Protokoll des IV Deutschen
Schriftstellerkongress, 1956, p. 77:
"erstens ist etwas als Perspektive dadurch bestimmt, dass es noch nicht existierend
ist. Würde es existieren, wäre es nicht Perspektive für die Welt, die wir gestalten;
zweitens : diese Perspektive ist aber nicht eine blosse Utopie..., sondern...die
notwendige Konsequenz einer objektiven gesellschaftlichen Entwicklung, die sich
dichterisch in der Entfaltung einer Reihe von Charakteren in bestimmten Situationen
objektive äussert, und drittens : ist sie objektiv, aber nicht fatalistisch...;es ist..die
Tendenz in der Wirklichkeit zur Verwirklichung ...durch Taten und durch
Handlungen ",

440 See :Wörterbuch der deutschen Gegenwartssprache, hrsg. R. Klappenbach, W.
Steinitz, vol. 4 ,1974, p. 2270:
"auf die Zukunft gerichtet" and " ".

441 Jean Gebser, Ursprung und Gegenwart, 1. Teil, Munich: DTV, 1973, p. 47:
"Während das Anliegen der Frührenaissance die Konkretisierung des Raumes war,
betrifft es in unserer Epoche die Zeit. Unsere Grundidee, der Versuch einer
Konkretisierung der Zeit und damit der Realisierung und Bewusstwerdung der vierten
Dimension, gibt uns die Handhabe für eine umfassende Erkenntnis unserer Epoche."

442 Gebser, ibid., p. 51:
...dass der unperspektivische Mensch (den man auch den hörenden Menschen nennen kann) noch vorwiegend auditiv war, während der perspektivische Mensch (den man auch als den sehenden Menschen bezeichnen kann) vorwiegend optisch ist.

Gebser, ibid., p. 52:
“...sie schafft Distanz zwischen den Menschen und Dingen. Distanzierung ist aber stets ein Kennzeichen sowohl von Bewusstwerdender Objektivierung als auch von der ihr voraufgegangenen, sie ermöglichenenden Entäussung und Freisetzung innerner Gegebenheiten, die in der Aussenwelt wiedergefunden und realisiert werden”.

Jean Gebser, Ursprung und Gegenwart, 1. Teil, Munich: Deutscher Taschenbuch Verlag (DTV), 1973, p. 354:
Lebewesen
sterbliche unsterbliche
Menschen Tiere
Sokrates Plato und andere

Jean Gebser, Ursprung und Gegenwart, 2. Teil, Munich: DTV, 1973, p. 491:
Das Ganze,
Ganzheit,
Durchsichtigkeit (Diaphanität),
das Geistige (Diaphainon),
Überwindung des Ich,
Realisierung der Zeitlosigkeit,
Realisierung der Zeithaftigkeit,
Realisierung der Begriffes Zeit,
Realisierung der Zeitfreiheit (des Achronon),
Zerbrechen des Räumlichen,
Zerbrechen des nur Systematischen,
Eindringen des Dynamischen,
Anerkennung des Energetischen,
Meisterung der Bewegung,
Vierte Dimension,
Überwindung des Patriarchats,
Verzicht auf Herrschaft und Macht, Gewinn an Intensität,
Klarheit (statt bloßer Wachheit),
Wandel des schöpferischen Ansatzpunktes.

“Das heisst aber nichts anderes, als dass in der räumlichen Anschauung nicht lediglich das Gesicht als Sinnesfunktion am Werke ist, wenngleich dieses, wie
abschliessend zu erörtern, ein entscheidendes sinnliches Konstitutionsmoment des Dinges ausmacht, sondern dass jeder Einzelaspekt bereits getragen ist von einem kategorialen, einheitsstiftenden Moment, wodurch die verschiedenen (intentionalen) Inhalte der Einzelaspekte unter der Einheit eines Sinnes gebunden sind. Meine perspektivische Raumanschauung ist von allem Urprung an ‘kategoriale’ Anschauung getragen von der Auffassung des Dinges als einem im Wechsel der Aspekte identischem. Als solche bewahrt sie vordem Zerfall in lauter getrennte Einzelwahrnehmungen und lässt damit die Anschauung des Dinges sein, was sie ist, eben eine perspektivische.”


“Dieses Vorwegnehmen, das alles per-spicere zum prospicere macht und in der Festlegung der zentralperspektivischen Darstellung auf einen Blickpunkt lediglich festgestellt ist, offenbart die Perspektivität als raumzeitliche-Verweisungs-Ganzheit, in der das Hier und Jetzt-dasein meines Wahrnehmens bei den in horizontaler Verweisung gegebenen Dingen immer schon das Dann eines unmittelbar folgenden Wahrnehmens impliziert.”


“Ich meine mit Perspektivität hier all das, was sich nicht der Struktur der Identität oder der Allgemeinheit fügt, was sich nicht hierarchisieren lässt, was das je und ständig Besondere im Allgemeinen bleibt.”

Ibid., 1983, p. 15:

“Die Annahme einer Dialektik von Perspektivität und Dezentrierung würde für die Vorstellung von Wahrheit nicht nur bedeuten, dass sie ein offener, unabschließbarer Prozess ist- was die genetische Erkenntnistheorie in einer bestimmten Interpretation noch mit zu beinhalten schien-, sondern auch, dass Wahrheit uneindeutig ist. Erkenntnis und Entscheidung wären also untrennbar. Und sie würde für die Vorstellung von Humanität bedeuten, dass diese an die konkreten Kommunikation in Geschichte und Gegenwart gebunden bleibt -wenn wir auch zugleich an allgemeinen Suppositionen eines, vernünftigen Menschseins und Miteinanders in einer gemeinsamen Lebenwelt festhalten müssen.”


"Perspektive als etwas der Natur eigenes ist... ein unerwartetes Geschenk der ... Physik an die Philosophie. Perspektiven sind weder Verzerrungen von irgendwelchen vollkommenen Strukturen noch Selektionen des Bewusstseins aus einer Gegenstandsmenge, deren Realität in einer Welt der Dinge an sich (noumenal world) zu suchen ist. Sie sind in ihrer wechselseitigen Bezogenheit aufeinander die Natur, die die Wissenschaft kennt."

"Der Erkenntnistheoretiker eignet sich...nicht zum unparteiischen Richter im Streit zwischen zwei Welt-Perspektiven um den Wahrheitsanspruch. Er soll sich...nicht auftönen, um diese Rolle zu übernehmen. Statt dessen soll er sich eine andere Aufgabe stellen: er soll dem tatsächlich sich vollziehenden Wechsel des wissenschaftlichen Begriffssystems und der ihm entsprechenden Welt-Perspektiven seine Aufmerksamkeit schenken und zu ermitteln trachten, welches die Triebfedern sind, die diesem Wechsel in Bewegung setzen. Die Aufgabe einer solchen Auffassung der Geschichte der Wissenschaften bildet den gefundenen Kern des geisteswissenschaftlichen Verstehens des Entwicklungsprozesses der Wissenschaft."


sich' gegeben, welches die verschiedenen Interpretationen gleichsam umkreisen. Dass wir dieses Ansichsein setzen, ist dadurch gerechtfertigt, dass, wenn wir auch in keiner Perspektive dieses Ansichsein erfassen können, es doch gegeben ist als eine kontrollfähige Instanz gegenüber willkürlichen Aussagen."


"ein himmelweiter Unterschied" zwischen "Parteilichkeit im Sinne einer Interpretation geschichtlicher Entwicklungen von einem bestimmten Parteistandpunkt aus, die die gewonnenen Ergebnisse zu fundamentalistischen Aussagen hypostasiert, die angeblich aus dem objektiven Geschichtsprozess selbst resultieren oder doch aus ihm ableitbar sind, und einer Interpretation vergangener Wirklichkeit aufgrund einer bestimmten, auf Wertgesichtspunkten, und/oder theoretischen Einsichten, die sich der Partialität ihrer selbst bewusst bleibt."

469 Mommsen, as in note 463, 1977, p. 448:

"Der perspektivische Character historischer Erkenntnis erstreckt sich sowohl auf die Selektion und Bewertung historischer Daten unter Wertgesichtspunkten als auch unter auf das kognitive Begriffsinstrumentarium des Historikers."

470 W. J. Mommsen, as in note 463, p.***:

"fast stets drei Gruppen von Fundamentalprämissen in den perspektivischen Konzeptionen ausmachen, die Träger der erkenntnisleitenden Interessen des Historikers sind und die übergreifenden Hypothesen, Paradig mata oder Theorien massgeblich beeinflussen...nämlich 1. eine bestimmte Auffassung vom Wesen des Menschen, 2. eine bestimmte Konzeption von sozialen Wandel, einschliesslich der Bedingungen, unter denen ein solcher eintritt oder auch nicht eintritt, 3. bestimmte Erwartungen über die zukünftige Entwicklung der jeweils gegenwärtigen Gesellschaft, gleichviel ob diese Erwartungen hypothetischen oder fundamentalistischen Charakter besitzen."


472 J. Rüsen, *Historischer Vernunft*, 1983, p. 130:

"Perspektivenerweiterung ist ein methodisch regelbarer Vorgang des historischen Denkens, in dem Standpunkte durchaus zur Geltung gebracht, zugleich aber auch (argumentative) auf andere Standpunkte bezogen werden."

473 J. Rüsen, *Rekonstruktion der Vergangenheit*, 1986, p. 93:

"Synchronisierung des Erkenntnissfortschritts mit der Perspektivenerweiterung."

474 J. Rüsen, *Rekonstruktion der Vergangenheit*, 1986, p. 93:

"Konsensobjektivität (Lübbe), dergemass "Geschichten" durch ihren Bedeutungsgehalt "Menschen"
mit unterschiedlichen Standpunkten, Bedürfnissen und Interessen im gesellschaftlichen Lebenszusammenhang in gleicher Weise zur Selbstverständigung dienen können" gibt "einerseits den historischen Erkenntnisprozess frei in die Pluralität unterschiedener perspektivenbildender Standpunkte, integriert aber zugleich die Pluralität standpunktunabhängiger historischer Perspektiven in der Einheit des Prozesses der Perspektivenerweiterung."


477 Kurt H. Busse, Die Ausstellung zur vergleichenden Entwicklungs-Psychologie der primitiven Kunst bei den Naturvölkern, den Kindern und in der Urzeit, in synoptischer Darstellung, Auf den Kongress für Aesthetik und allgemeine Kunstwissenschaft, Berlin, 1913, pp. 3-4:

"Die Entwicklung der körperlichen Verkürzung, in der übrigens die volle Faceprojection (Buschmann, Paläolithikum, Eskimo) der eigentlichen Dreiviertelansicht vorausgeht, wird in Zusammenhang mit der räumlichen Perspektive behandelt.... Auch das Problem der umgekehrten Perspektive (Wulff) wird durch Beispiele aus der japanischen und Buschmannkunst illustriert. Die Entwicklung der Landschaftsdarstellung wird via der Vogelperspektive mit Umlegung aller Häuser und Bäume in der Fläche bis zur Ausbildung der Fusslinie, später der Stanebene und schliesslich des Horizontes vorgeführt, unter Betonung der Schwierigkeit des Mittelgrundes."

478 Ibid., p. 8:

"Die Bezeichnungen Face oder Profilstellung müssen daher als Masstabe für die bildliche Darstellung der Gestalt irreführend erscheinen. Wir lehnen demnach sowohl das Frontalprinzip wie die Profiltheorie ab und setzen diese Begriffe durch die aus der materiellen Schwierigkeit der beiden Ausdrucksmittel sich ergebenden, also ästhetischen Gesetzsmässigkeiten die wir als die Schemata des Flächenzwanges und des Blockzwanges beschreiben."

VI. TRANSFORMATIONS


481 M. Mauss, Essai sur le don. Forme et raison de l'échange dans les sociétés archaïques, ***


M. Guyau, *L'art au point de vue sociologique*, Paris: Félix Alcan, 1889: Chapitre IV: "L'expression de la vie individuelle et sociale dans l'art".

La sociologie d’après l’ethnographie.


Georg Simmel, as in note 425 above, p. 3: "Bei der Socialwissenschaft findet nur ein quantitatives Überwiegen des kombinatorischen Elementes gegenüber anderen Wissenschaften statt, woher es dann bei ihr besonders gerechtfertigt erscheint, sich die Gesichtspunkte, nach denen ihre Kombinationen erfolgen, zu theoretischem Bewusstsein zu bringen."

Simmel, p. 182: "Zum mindesten scheint zwischen diesen beiden Bestimmungen des Sittlichen, dem in der Idee einer ewigen Wertordnung gipfelnden Apriorismus und dem am Begriff der Person orientierten 'emotionalen Wert-Perspektivismus', eine wirkliche Einstimmigkeit nicht hergestellt zu sein."

Simmel, p. 184: "Das Prinzip der ethischen Monadologie, des Wertperspektivismus wird auch von denen in der Tat erhärtet, die ihm in der Lehre nur einen bescheidenen Raum gönnen."

Soziologie. Untersuchungen über die Formen der Vergesellschaftung.

Georg Simmel, as in note 479 above, p. 13: "Die Auflösung der Gesellschaftseel in der Richtung der modernen Geisteslebens überhaupt."

Georg Simmel, as in note 479 above, p. 41 note to 16: "Schon Simmel hatte die Soziologie (dem Sinne nach) als Beziehungslehre aufgefasst."

Allgemeine Soziologie... as in note 471.


Leopold von Wiese, as in note 432, p. 24.

Leopold von Wiese, as in note 432, pp. 11-14.

Leopold von Wiese, as in note 432, p. 676.

Leopold von Wiese, as in note 432, p. 39.

Leopold von Wiese, as in note 432, p. 49.

Leopold von Wiese, as in note 432, p. 677.

Leopold von Wiese, as in note 432, p. 348.

Leopold von Wiese, as in note 432, p. 36.

Leopold von Wiese, as in note 432, p. 380.


Becker, as in note 442, above, p. 94.


Ibid, p. 221: "das gesellschaftliche Urphänomen."

De Folter, as in note 502, p. 158:

"Mit der Verschränkung der Perspektiven übt er Kritik an dem blossen Nach und Nebeneinander isolierter Elementen des objektivierenden Denkens."

Theodor Litt, as in note 503, p. 83:

"Es sind nicht gleichartige, nicht vergleichbare, es sind zusammengehörige, sich in wechselseitig bestimmende, miteinander verschrankte Perspektiven, die in mir und in dir leben; und mein, dein unmittelbares Wissen um sie ist zugleich ein Wissen um dieses ihr Ineinander greifen."


Cf. de Folter, as in note ****, 1983, p. 160:

"Taking the role of the other "impliziert immer eine Reziprozität der Perspektiven"."

George Herbert Mead, *Philosophie der Sozialität. Aufsätze zur Erkenntnisanthropologie*, hrsg. H. Kellner, 1969, 144:

"Das Wahrnehmungsobjekt steht dem Organismus als einem physischen Objekt gegenüber. Diese Situation wird als Perspektive bezeichnet. Die Beziehung zwischen Wahrnehmungsfeld und Organismus in der Perspektive ist sozial."

Mead, as in note 504 above, p.***: "schon immer in einer Perspektive [befindet], die der Gemeinschaft angehört, innerhalb derer das Selbst entstanden ist."

Auf der Ebene der konkreten, faktischen Abstimmungsprozesse kann die Bestimmung der Reziprozität als eine ideale und egologisch angesetzte Normalität überwunden werden. Es kommt darauf an, die Normalität der Reziprozität der perspektiven nicht länger als eine egologisch konstruierte Idealität zu fixieren, sondern als faktischen, auf ein ursprüngliches Wir bezogenen Prozess zu fassen.


Marcel Réja, *L’art chez les fous*, Paris: Société du Mercure de France, 1907, [i.e. 1908], p.131:

"Suivre les principales étapes de l’évolution des dessins d'enfants c'est donc assister à l'enrichissement progressif de sa conscience à la conquête lentement effectuée de l'univers qui l'environne."


"Die beiden ursprünglich erfassten Momente sind hierbei, ‘Helligkeit, Sichtbarkeit’, bzw. ‘hell und sichtbar machen’ und andererseits ‘vor Augen stellen’; die ‘Erhellung’ lenkt die Aufmerksamkeit auf sich, das ‘vor Augen Gestellte’ kommt in den Bereich der Wahrnehmung. Es ist wohl (kurz deutsch angedeutet) das Vorführen (Aufdecken) der Dinge für den Beschauer oder umgekehrt das führen des Beschauers (beschauenden Blickes) zu den Dingen hin, was die mehrstämmige Sippe der indoeuropäischen Zeichen-Wörter in der Regel trifft."

Veronika Ullmer-Ehrich, Willem Levelt, "Psycholinguistik. Eine imaginäre Tour durch die Wohnung", MPG Spiegel, Munich, no. 6., December 1980, p. 5:
" Lokaladverbien wie 'rechts', 'links', 'vorn', 'hinten' drücken wesentliche topologische Beziehungen im Raum aus. Sie gehören zu den sogenannten 'indexikalischen' oder 'deiktischen' Mitteln der Sprache. Diese 'verweisen' in ihrer Bedeutung auf die Sprechsituation, in der sie geäußert werden. Dabei sind unterschiedliche Verankerungen in der Situation möglich. 'Rechts' kann rechts vom Sprecher oder rechts vom Zuhörer sein. Eine (imaginäre) Wandlung kann von einem konstanten Beobachterstandpunkt aus beschrieben werden oder aus der Perspektive des Wandern den. Im ersten Fall bleibt die Rechts/Links-Orientierung konstant, im zweiten ändert sie sich mit jeder Richtungsänderung des Wandern den. Darüber hinaus lassen die indexikalischen Lokaladverbien neben der situationsabhängige sogenannte 'intrinsische' Verwendung zu, in der die Blick- oder Wandersungsrichtung des Sprechers und/oder Hörers keine Rolle spielt.

Der Sprecher steht nun vor der äusserst komplexen Aufgabe, nicht nur eine geeignete Perspektive auszuwählen. Er muss die gewählte Perspektive auch eindeutig kennzeichnen, Perspektiven-Mehrdeutigkeiten vermeiden und jeden Wechsel der Perspektive anzeigen. Ein Mittel, das häufig verwendet wird, um die gewählte Perspektive eindeutig zu kennzeichnen, besteht darin, räumliche Deiktika durch zeitliche zu ersetzen. (Nicht 'An der Fensterwand steht ein Tisch und links daneben ein Schrank' sondern 'An der Fensterwand steht ein Tisch und dann kommt ein Schrank'."

Fritz Novotny, Cezanne und das Ende der wissenschaftliche Perspektive, Vienna: Schroll, 1939.
During this period Panofsky (1927) also wrote his landmark essay on perspective as a symbolic form, but major discussions concerning its implications did not begin until

It is noteworthy that national standards for technical drawing were established with respect to distinctions between first angle (Britain) and third angle projection (United States) in the 1920’s and 1930’s.


"Le problème de la fenêtre donna 'La Condition humaine'. Je plaçai devant une fenêtre vue de l'intérieur d'une chambre, un tableau représentant exactement la partie de paysage recouverte par ce tableau. L’arbre représenté sur ce tableau cachait donc l'arbre situé derrière lui, hors de la chambre. Il se trouvait pour le spectateur à la fois à l'intérieur de la chambre sur le tableau et à l'extérieur dans le paysage réel. Cette existence à la fois dans deux espaces différents est semblable à l'existence à la fois dans le passé et le présent d'un moment identique comme cela se passe dans la 'fausse reconnaissance'."


"Il est possible pourtant d'obtenir une image nouvelle qui résistera mieux à l'examen du spectateur. Un grand œuf dans la cage parait être la solution. Occupons-nous maintenant du battant de la porte: celui-ci peut s'ouvrir sur un paysage vu à l'envers ou bien le paysage peut être peint sur le battant. Mais essayons quelque chose de moins gratuit: à coté du battant de la porte, faisons un trou dans le mur, trou qui est aussi une issue, une porte. Perfectionnons encore cette rencontre en réduisant les deux objets à un seul: le trou se place tout naturellement dans le battant de la porte. Et par ce trou nous verrons l'obscurité; cette dernière image parait à nouveau s'enrichir si on éclaire la chose visible cachée dans l'obscurité car notre regard veut toujours aller plus loin et voir enfin l'objet, la raison de notre existence".


For a basic description of the difference between vector and raster graphics see: William G. Mitchell, *The Re-Configured Eye*, as in note 429 above, pp. 4-6.


A more detailed analysis of these problems would explore how Lansdale’s approach, which is an extension of image precision algorithms, reverses the direction of projection
used in Renaissance perspective, whereas object precision algorithms maintain the
direction of the projection used in Renaissance perspective.

566 Benoit Mandelbrot, The Fractal Geometry of Nature, New York: W. H. Freeman,
1977.

567 Michael Fielding Barnsley, Fractals Everywhere. The First Course in Deterministic

1993, Colour Pl. 4.

569 The Kodak Guide to Imaging, ed. Michael D. Gurley, Frederick P. Burger, Rochester:
Eastman Kodak, 1993, p. 5.

Applications and Explorations, ed. Alan Wexelblatt, Boston: Academic Press, 1993,
pp.163-197.

571 For a further discussion of these problems see the author’s “Percezione, prospettiva e
rappresentazione nell’America Settentrionale” in: Specchi americani; riflessi e
metamorfosi delle tradizioni filosofiche europee nel nuovo mondo, ed. Caterina Marrone,
Sepolcro; Contatti 6).

572 Heinrich Klotz, Florian Rötzer und Peter Weibel, “Perspektiven der Computerkunst.
Ein Gespräch”: Künstliche Spiele, ed. Georg, Hartwagner, Stefan Iglhaut, Florian Rötzer,
Munich: Boer, 1993, p. 123:

"Die Simulation ist ein weiterer Schritt weg vom Fluchtpunkt der
Renaissanceperspektive hin zu einer Scheinwelt die für das Subjekt virtuell wirklich
ist. Der Mensch kann sich diese Scheinwelt so vorgaukeln, als könne er in ihn leben,
as würde er selbst als dreidimensionales Wesen in einem künstlich geschaffenen
dreidimensionalen Raum existieren. Das ist eine neue Thematik, die man ausloten
sollte."

573 Charles Champlin, George Lucas. The Creative Impulse. Lucasfilm’s First Twenty
Years, New York: Harry Abrams, 1992. For a more detailed study see: Thomas G. Smith,
Industrial Light and Magic. The Art of Special Effects, New York: Ballantine Books,
1986.

574 Cf. Steve Aukstakalnis, David Blatner, The Art and Science of Virtual Reality. Silicon
Mirage, Berkeley: Peachpit Press, 1992, pp. 238-242 re: two programmes that have been
developed to this end, namely, n-Vision and Capri.

575 Kim Michael Fairchild, “Information Management Using Virtual Reality-Based
Visualizations”, in: Alan Wexelblatt, ed., Virtual Reality Applications and Explorations,


577 While superficially authoritative in tone, there were a number of details in Jay’s work
which were incorrect. The Latin lux refers to the source of light whereas lumen refers to
its effects and not conversely as Jay (1993, 29, 303) claimed. According to Jay (31)
extramission was “laid to rest in the late Middle Ages. In fact this theory continued to
receive serious commentaries until the mid seventeenth century particularly in the
context of medical dissertations. Jay claims (65) that Leonardo was one of the earliest
users of the camera obscura. As we have shown the documented evidence goes back at
least until the ninth century. (see above p. 125**). The first edition of Pélerin was 1505 not 1504 as Jay (68) claims.


579 Jay did not cite the more recent work by Norman Bryson, Looking at the overlooked, London: Reaktion, 1990.


582 Spielmann, 1993, 56:
"Szenisch fungiert der Videoschirm als Fenster, worin allerdings kein tatsächliches Aussenbild erblickt, sondern vielmehr eine sekundäre Ebene der Mediatisierung vorgestellt wird. Das bewegte Innenbild reflektiert die Binnenstruktur des Mediums Film: Bewegung und Zeitlichkeit. Strukturell muss dieser intermediale Diskurs als Indiz für eine Verschiebung auf der Achse der Sichtbarkeit verstanden werden....Das bildintegrierte Monitorbild trägt die doppelte visuelle Metapher in sich: Diegetisch ist diese gerahmte Bildstellung dem Prinzip der Abimierung (der Einspiegelung des Ausserhalb) verpflichtet; bezogen auf den televisionären Status kommt ihr jedoch die extra-diegetische Funktion einer Inferierung zu, wobei die (beliebige) Einfügung anderer Bilder in Format beschränkt bleiben."

583 Ibid., pp. 59-60:
"Cluster, beziehungsweise ‘visueller Cluster’ bedeutet folglich eine Gleichzeitigkeit, die als innerbildliche Verschachtelung diaphaner Bildebenen auftritt und, elektronisch unterstützt, zur absoluten, punktuellen Verdichtung strebt. Inferierung schliesst serielle, sukzessive und andere kontinuierliche verlaufsformen in einer neuen Montageform kurz zu einem kartographischen Bildraum. Die Metaphern des ‘Webrahmens’ (Deleuze) und der Veräumlichung (Jameson) erfahren bei Greenaway eine konkrete umsetzung durch die Akkumulation der Rahmenfunktion und ihre Verdichtung zu einem kinematischen Bildcluster."

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One of the interesting aspects of the increasingly international scene is that the same software is being used for different ends in Japan, Canada and the United States, while at the same time, Toronto firms such as Topix and Spin Productions are creating applications for Canada, Japan and the United States.

This has led to a new field of scientific visualization. For a basic introduction see: Richard Mark Friedhoff, William Benzon, _The Second Computer Revolution. Visualization_, New York: Harry Abrams, 1989.


1. Standard
2. Personal
3. Internal Use
4. For Information
5. Internal Use Info
6. For Notification
7. For Feedback

Fig. 48. Seven different levels of access used in Digital’s Linkworks Software.


The following is taken from: Newsgroups: sci.crypt, talk.politics.crypto,sci.answers,news.answers, talk.answers; Subject: Cryptography FAQ (01/10: Overview); Date: 17 Jan 1994.

Organization: The Crypt Cabal; Reply-To: crypt-comments@math.ncsu.edu
Many people have contributed to this FAQ. In alphabetical order: Eric Bach, Steve Bellovin, Dan Bernstein, Nelson Bolyard, Carl Ellison, Jim Gillogly, Mike Gleason, Doug Gwyn, Luke O'Connor, Tony Patti, William Setzer. We apologize for any omissions:

"6.8. What is `authentication' and the `key-exchange problem'? The `key exchange problem' involves (1) ensuring that keys are exchanged so that the sender and receiver can perform encryption and decryption, and (2) doing so in such a way that ensures an eavesdropper or outside party cannot break the code. 'Authentication' adds the requirement that (3) there is some assurance to the receiver that a message was encrypted by 'a given entity' and not 'someone else'.

The simplest but least available method to ensure all constraints above are satisfied (successful key exchange and valid authentication) is employed by private key cryptography: exchanging the key secretly. Note that under this scheme, the problem of authentication is implicitly resolved. The assumption under the scheme is that only the sender will have the key capable of encrypting sensible messages delivered to the receiver. While public-key cryptographic methods solve a critical aspect of the `key-exchange problem', specifically their resistance to analysis even with the presence a passive eavesdropper during exchange of keys, they do not solve all problems associated with key exchange. In particular, since the keys are considered 'public knowledge,' (particularly with RSA) some other mechanism must be developed to testify to authenticity, because possession of keys alone (sufficient to encrypt intelligible messages) is no evidence of a particular unique identity of the sender. One solution is to develop a key distribution mechanism that assures that listed keys are actually those of the given entities, sometimes called a 'trusted authority'. The authority typically does not actually generate keys, but does ensure via some mechanism that the lists of keys and associated identities kept and advertised for reference by senders and receivers are 'correct'. Another method relies on users to distribute and track each other's keys and trust in an informal, distributed fashion. This has been popularized as a viable alternative by the PGP software which calls the model the 'web of trust'.

Under RSA, if a person wishes to send evidence of their identity in addition to an encrypted message, they simply encrypt some information with their private key called the 'signature', additionally included in the message sent under the public-key encryption to the receiver. The receiver can use the RSA algorithm 'in reverse' to verify that the information decrypts sensibly, such that only the given entity could have encrypted the plaintext by use of the secret key. Typically the encrypted 'signature' is a `message digest' that comprises a unique mathematical 'summary' of the secret message (if the signature were static across multiple messages, once known previous receivers could use it falsely). In this way, theoretically only the sender of the message could generate their valid signature for that message, thereby authenticating it for the receiver. 'Digital signatures' have many other design properties as described in Section 7."

On the problems involved see, Ethics, Copyright and the Bottom Line, ed. Stewart McBride, Camden: Center for Creative Imaging, particularly, Fred Ritchin, “An Image Based Society”, pp. 29-36. For reference to Kodak’s research see: “When its created it’s