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Panofsky's Perspective: a Half Century Later

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Erwin Panofsky *(1892-1968)* is a figure of interest not only because he was one of the greatest art historians of our century, but particularly because he was one of those rare beings whose commitment to detailed facts never obscured an ongoing concern for fundamental questions. He was constantly asking how the history of artistic styles related to changing world views, ever seeking to establish underlying bonds linking philosophy, art, science, mathematics, indeed all realms of human experience. He was "Pan" in more senses than one.

While some might reasonably insist that his pioneering contributions to the study of iconography constitute his chief claim to enduring recognition, the present author finds in Panofsky's contribution to the history of perspective the clearest example of how wide ranging his detailed interests could be. There are at least two other reasons for concentrating on what might at first appear a peripheral aspect of the great man's achievement: 1) it will help suggest how far beyond the narrow bonds of art history Panofsky's influence has been felt; *2)* it may offer a salutary reminder to an age of specialists that art history can involve more than looking at pictures.

Panofsky's interest in (linear) perspective can be traced back to his doctoral dissertation on Dürer's aesthetics *(1914)* in which he suggested that Renaissance art theory involved two central problems, namely, accuracy (*Richtigkeit*) and beauty. Accuracy, he claimed, entailed a "geometrical-perspectival and empirical-scientific knowledge", but he did not elaborate. In his thesis Panofsky concentrated on exploring the problem of beauty.

The following year, in *Dürers Kunsttheorie (1915)* he turned to consider the problem of accuracy in some detail. Accuracy, he now claimed, basically involved representing objects "as they are". This naturally varied according to the medium. In sculpture it meant congruence of measured size. In the case of painting accuracy meant representing something which was equivalent to what was seen and this, in turn, was precisely the problem of linear perspective.

At this stage Panofsky was still convinced that the practice of Renaissance linear perspective had found its theoretical foundation in the science of optics established by Euclid in Antiquity. The Mediaeval period had codified Euclid's ideas under the heading of *perspectiva* and, according to Panofsky, when the painter's practice came into being it was specially termed *perspectiva pingendi* or *perspectiva artificialis* to distinguish it from the traditional science of optics, which was now termed *perspectiva communis* or *perspectiva naturalis*. Panofsky went on to cite Dürer's paraphrase of Euclid's *Optics* and proceeded to argue that Dürer's first perspective method entailed a groundplan and elevation technique. Following Staigmüller (1891), he then claimed Dürer's second method (the so-called *nähere Weg*) was a simplified version of his first method rather than a distance point construction. These arguments accorded well with his general thesis which claimed Dürer's perspective had its origins in Italian theory.

Although the details of Panofsky's discussion need not concern us here it is worth pausing for a moment to consider one of his footnotes. Here (pp. 21-2) Panofsky admits that "recent studies (Hillebrand etc.) have shown, that even a single stationary eye does not see in the sense of Euclidean optics". He realizes this implies that "a strictly correct perspective drawing can often appear less natural than a correct one" and decides, therefore, to define "right" and "wrong" perspectival representation strictly in terms of their having or not having accordance with geometrical perspective. This statement is important because it reveals he is already concerned in 1915 with the problems he will approach much more intensively and very differently in his famous lecture of 1924-25.

Before we proceed to examine this lecture we must at least mention two significant articles written in the interim. One (1915) presented an analysis of Alberti's perspective discussion to show it involved a *costruzione legittima* method and not a distance point construction as Janitschek (1887) and others had assumed. The second (1919) was devoted to the Scala Regia in the Vatican and demonstrated just how revealing could be the study of perspectival and optical considerations in analysing not only architectural style, but also cultural history generally. An abridged and revised version, dedicated to Hermann Voss, appeared in 1922. Panofsky's lecture *Die Perspektive als Symbolische Form (*1924-25, published 1927) at the Warburg Institute (then still at Hamburg) marked his first (and last) serious attempt to explain changes in perspectival methods in terms of changing world views. The neo-Kantian framework of explanation created by his friend Ernst Cassirer had articulated a distinction (1910 cf. 1905) between two fundamentally different approaches to science, one which dominated Antiquity and emphasized substance (and definition), the other which evolved in the Renaissance and concentrated on function (and relation). Cassirer had, moreover, implied the method of Antiquity was linked with notions of sensuous space (unhomogeneous and anisotropic) and that the method which originated in the Renaissance was linked with notions of mathematical space (homogeneous and isotropic).

Other historians of science (Cohn, 1896; Duhem, 1909; Olschki, 1924) had been stressing the importance of a shift from a finite to an infinite world view in explaining the fundamental differences between Antiquity and the Renaissance. Meanwhile, an important art historical tradition which is associated with the name of Alois Riegl, had postulated that the Ancients represented objects in isolation while the system of spatial relations was an achievement of the Renaissance. Panofsky fused these methods of explanation to create his own. The Ancients, he posited, had accepted a finite world view which implied a notion of aggregate space (finite, unhomogeneous and anisotropic). In the course of the Middle Ages and the Renaissance this was transformed into an infinite world view which implied a concept of system space (infinite, homogeneous and isotropic). These different kinds of space required in turn different approaches to "perspective".

This scheme forced a revision of his earlier (1915) claim that Euclid's *Optics* had been the foundation of linear perspective. For if Euclid's *Optics* was derived from notions of aggregate space it followed that Euclid's text must itself be fundamentally at variance with the principles of linear perspective. Panofsky met his difficulty with a brilliant - albeit as we shall see presently, questionable solution. Linear (or plan) perspective, he claimed, had as its fundamental tenet an inverse relation between size and distance. Panofsky then turned to Euclid's *Optics* for evidence to show the Ancients had not discovered this fundamental tenet. In proposition VIII of Euclid's text he found the answer he wanted: following the implications of an earlier postulate that apparent size depended strictly on angular size, Euclid's theorem stated there could be no simple proportional relation between size and distance. Panofsky assumed a necessary connection between theories of vision and representation and could thus proceed to claim Euclid's *Optics* implied an "angle perspectival" method, as opposed to the "plane perspectival" method developed in the Renaissance.

Nor did he stop here. Convinced that this "angle perspectival" method necessarily corresponded to psychological and physiological realities of vision he postulated it must have involved a curved projection plane corresponding to the shape of the retina. This curved plane of the "angle perspectival" method could then be neatly contrasted to the straight (and parallel) projection plane of the "plane perspectival method" which corresponded to the realities of geometrical space and thus marked an abstraction from the subjective aspects of the visual process.

Panofsky could now weave a systematic explanation at once convincing and concise. In Antiquity a finite world view had led to a notion of "aggregate space" corresponding to "sensuous space". This had precluded an interest in distance and had required instead an angle perspectival method involving curved projection planes. By the Renaissance there had evolved a concept of infinity which implied "system space" and required an interest in distance that led naturally to the invention of "linear (or plan) perspective" involving straight (and parallel) projection planes. In other words, his a priori framework of explanation now allowed Panofsky to explain the invention of linear perspective as the direct implication of a concept of infinity.

His assumption that theories of vision and representation were necessarily connected required him to take his claim one step further. If a concept of infinity transformed perspectival methods, it followed that the traditional theory of vision must have been transformed. He looked to Renaissance editions of Euclid's *Optics* and found in Pena's edition (1557) what he thought was proof of the change he predicted. He could thus conclude that the invention of linear perspective in the Renaissance had literally entailed a new way of seeing.

Panofsky's great erudition added weight to his already convincing arguments. His painstaking footnotes contain a host of references to literature in philosophy and psychology as well as the history of art and science, and represent a contribution to learning in themselves. For our purposes it may suffice to note that they contain (1) one of the first scholarly discussions of the tensions which continued throughout the Renaissance between Euclidean theories of angular size and the principle of linear perspective (a scholar less honest than Panofsky would not have included in his footnote evidence that undermined the thrust of the arguments in his text); (2) an expanded version of his earlier (1915) distinction between the two principal methods of Renaissance linear perspective in which he identified the "costruzione legittima" as the theoretical method invented by Brunelleschi and claimed that the "distance point construction" had its origins in a northern workshop tradition and only became known in Italy following Danti's publication of Vignola's *Le due regole …* (1583) and (3) a re-interpretation of Pomponius Gauricus perspective method by which he claimed it was identical to Alberti's "costruzione legittima".

Die Perspektive marked Panofsky's most thorough search into the history of perspective and we shall wish, therefore, to consider its sources, its influence, anl the problems it involves, once we have completed our survey of his other writings on the subject. We need only mention in passing his two articles on the Friedsam Annunciation (1935, 1938) in which he explored further the northern workshop tradition which he thought had led to the development of the distance point construction. *The Codex Huygens and Leonardo da Vinci's Art Theory* (1940) contained a fuller discussion of Renaissance perspective albeit much of what he wrote here was a restatement of conclusions reached earlier. Nonetheless, it was a restatement with a new slant. He now emphasized anew (p. 91) the quest for "objective correctness" involved in linear perspective (cf. 1915, pp. 7 ff.). In an earlier essay (1927, p. 280) he had suggested artists played some role in the development of modern science. He now set forth his idea more dramatically (p. 91):
"It was the effort of theorizing of artists and not of academic professors which was chiefly responsible for the efflorescence of modern natural science."

His earlier work had contrasted the sensuous space of Euclidean optics (and its corresponding curved perspective method) with the abstract mathematical space of linear perspective. He implicitly continued to accept this explanation (p. 94) but now stressed (p. 97) the difference between Antiquity and the Renaissance in terms of a contrast between "a mathematical theory of vision" and "a mathematical theory of representation". Moreover, he now approached linear perspective as a method of establishing (p. 92) the "visual image appearing in the eye .., on a general scientific basis". In short he was now claiming that linear perspective corresponded simultaneously to optical experience and the laws of mathematical space.

But the *Codex Huygens* was significant for another reason also: it contained numerous examples of precisely the curvilinear method Panofsky had assumed the Ancients used (cf. 1927, pp. 261-G8 and pp. 292-98). He thus had new reason for maintaining his earlier contention that Euclidean optics implied a curved projection plane. Why this method should suddenly have appeared in the Renaissance he did not attempt to explain. Instead he stressed its being an exception to the general (Brunelleschian) rule and described it fancifully as "perspectiva naturalis in usum artificum".

Panofsky returned briefly to the-problem of Renaissance perspective in his great work on *Albrecht Dürer (1943).* Here he contrasted once more the perspective practice of the Northern artists with the perspective theory of the Italians. The Northern practice had, he claimed *(pp. 248-9):* "developed quite independently of that mathematical analysis of the process of vision which was known as *οπτικη* or *optica* in classical Antiquity, and as *prospectiva* or *perspectiva* in the Latin Middle Ages". Quietly ignoring his earlier *(1927, 1940)* contention that Euclidean optics implied a curvilinear method fundamentally opposed to the principle of linear perspective, Panofsky now turned to the Italians and claimed (p. *249)* Brunelleschi had invented the *costruzione legittima* involving groundplan and elevation when he thought of "applying the Euclidean theory of vision to the problems of graphic representation". This method proved too unwieldy for common use and consequently an abbreviated method, first described by Alberti, became adopted. Still anxious to uphold his earlier thesis that Dürer was "much indebted to the Italians", Panofsky went on to repeat his claim equating Dürer's first method with the *costruzione legittima* and the so-called *nähere Weg* with Alberti's abbreviated version, thereby continuing to ignore the clear discrepancies separating Dürer's second method from Alberti's costruction which Schuritz *(1917)* had signalled and Ivins *(1938)* had stressed (see Carter, *1970, p. 853).*

Panofsky's *Early Netherlandish Painting (1953)* contained another summary of his earlier writings and as regards perspective is perhaps noteworthy only for its succinct restatement of his *a priori* neo-Kantian approach (p. 5): "a correct perspective construction presupposes and does not engender the concept of space it manifests".
In *Galileo as a Critic of the Arts (1954)* Panofsky explored briefly how problems of "ânamorphosis" (trick perspective) related to Galileo's science and found evidence to claim that (p. *20):* "both as a scientist and as a critic of the arts he may be said to have obeyed the same controlling tendencies.

Finally, in *Renaissance and Renascences in Western Art (1960,* the article of *1944* had merely alluded to perspective) he returned to present a simplified version of the themes explored in *Die Perspektive*.... Once again, he contrasted (p. *122* ff) the finite and unhomogeneous notions of space in Antiquity with the infinite and homogeneaus concept of space implicit in Renaissance (linear) perspective. The tension he had described earlier between the "angle perspectival" and the "plan-perspectival" methods he now characterized as a difference between an "angle axiom" and a "distance axiom". In his earlier works *(1927, 1940)* he had remained unclear whether the projection methods of Antiquity involved merely a curved arc or a sphere. He was now clear in his belief it must have been the latter and used this as a further reason why linear perspective was inconceivable in Antiquity (p. *129):*

> since even the simplest curved surface cannot be developed on a plane, no exact perspective construction could be evolved or even envisaged until the urge for such a construction became stronger than the spell of the "distance axiom" which is the foundation of classical optics.

But there remained another ambiguity which Panofsky either overlooked or chose not to confront, namely, the relation of linear perspective to the visual process. For, on the one hand he claimed (p. *123)* linear perspective entailed a record of "direct visual experience", but on the other hand he continued to insist that classical optics (p. *128):"*considered our sphere of vision quite literally as a "sphere" - an assumption, incidentally, which more nearly agrees with physiological and psychological reality than that which underlies Brunelleschi's rectilinear construction."

We need not wonder that Panofsky's writings sparked off debates whether linear perspective does or does not conform with the laws of optics. Is it significant that although Panofsky's footnotes reveal his familiarity with secondary literature of the *1950's,* he made little attempt to take a serious stand on the issues that were being raised. Perhaps he was conscious that "Die Perspektive" written when he was only *32* was destined to remain his most impressive contribution to the subject. It is, in any case, fitting we should now return to it and examine more closely its sources, its influence and problems it entails.

Notwithstanding the work of Neri *(1961),* Dalai *(1961)* and Bazin *(1968);* the question of Panofsky's sources for "Die Perspektive" has remained largerly unexplored and has resulted in at least three misconceptions: one regarding his originality in treating perspective as an aspect of style; another concerning his originality in claiming Renaissance art anticipated the discoveries of early modern science and a third regarding the influence of Guido Hauck on his ideas.

The first misconception has been spread by Gioseffi *(1965, p. 768)* who suggested it was not until the *1920's* that art historians "were beginning to face the problem of the historical significance of linear perspective" and more recently by von Einem *(1968, p. 9)* who claimed Panofsky was the first to approach perspective as a stylistic problem of artists rather than as a technical-mathematical problem.

This is simply not true. Witting *(1878) is* already clear about the importance of space and perspective in studying Piero della Francesca and devotes an entire chapter to perspective in his influential *Kunst und Christentum (1903).* Kern *(1905)* specifically discusses how perspective can serve as a tool in stylistic analysis and later *(1912, p. 40)* cites Kallab *(1900)* as one of his own sources. Rapke *(1902, pp. 3-4)* states he will systematically study Dürer's perspective as a means of his artistic development, an. approach which Schuritz *(1916)* follows and expands upon. Berstl *(1920)* in his book on early Christian painting also pursues this approach and is particularly interesting because he devotes his final chapter to a brief survey of literature on the problem of space, discussing in turn, Schlick *(1918, 1919),* Riegl *(1901),* Tross *(1917),* Hildebrand *(1910),* Hinton *(1886, 1900),* Wulff *(1907),* Schweitzer *(1919),* Schmarsow *(1905)* and Dvorak *(1918).* The bibliography to Hille's *Raum und Raumdarstellung (1924)* confirms our impression the topic was being discussed at the time as, for that matter, does Panofsky's own bibliography which mentions Kallab, Riegl, Witting, Wulff, Schuritz, Berstl and of course, - as Dalai has pointed out - Kern and Mesnil. Hence Panofsky was not the first to use perspective as a means of analysing style.

The second misconception, that Panofsky was original in noting the importance of Renaissance art for early modern science, was probably started by Panofsky's friend Cassirer who, in his *The Individual and the Cosmos in Renaissance Philosophy* (1927, p. 182) cited Panofsky as having shown "that the theory of perspective anticipated the results of modern mathematics and cosmology". Since then historians of science such as Randall (1957, p. 208) and Santillana (1959, p. 63 cf. 1968) have cited Panofsky when emphasizing the role of art in early modern science. But the idea does not originate with Panofsky. We find it in Loria's chapter on perspective and projective geometry in Cantor's history of mathematics, 1924, IV, p. 580) and if we delve back into the neo-Kantians we discover that Cohen - building upon ideas of Herder and von Humboldt - had already propounded clearly the idea of artists as scientists (*Künstler als Forscher*) before the turn of the century (1889, pp. 228-29). Cohen's *Asthetik des reinen Gefühls* (1912, pp. 26-30) repeats this idea and not only stresses the links between artistic work (*künstlerische Arbeit*) and scientific logic (*wissenschaftliche Logik*) but actually mentions in this context perspective and anatomy. When we realize these are the very topics Panofsky later (1915) isolates in his discussion of the problem of accuracy, it becomes obvious that any attempt to assess honestly the question of Panofsky's originality would have to examine more carefully just how deep runs the neo-Kantian influence in his work.

A third misconception concerns the role of Guido Hauck in influencing Panofsky, Gioseffi (1965, pp. 767-68) has, for example, rightly emphasized the importance of Hauck's study of "subjective perspective" (1879) for understanding Panofsky's theories of curvilinear perspective, but has claimed Hauck had "no immediate following" and that his ideas unexpectedly "returned to favour" fifty years later "with the work of Kern and Panofsky". This again is not quite true. Witting (1903, p. 108) refers directly to Hauck as having established that linear perspective does not accord with subjective visual impressions. The idea is repeated without acknowledgment by Mesnil (1913, p. 150) and again in his book on Masaccio (1927, p. 118) which lists Hauck in the bibliography. To better understand why Hauck was not forgotten it is helpful to recall the work of Hillebrand (1902) which appeared to provide scientific evidence the eye perceived curved lines as being straight. His conclusions influenced Mach (1905, pp. 337-52) in making his important distinction between the physiological space of vision and touch (which is finite, anisotropic and homogeneous) and metrical space (which is infinite, isotropic and homogeneous). Mach's idea was adopted by Cassiser, first in Subs*tance and Function* (1910, p. 105) and later in *The Philosophy of Symbolic Forms* (1925, II, p. 83). Panofsky (1927, p. 292), in turn, cited Cassirer as a source for his own distinction between "aggregate space" and "system space".

Interestingly enough Panofsky is also familiar with Hillebrand's work first hand (1927, pp. 294-95, cf. 1915, p. 21) and even shows familiarity with Poppelreuter (1911) one of Hillebrand's critics. We can safely suggest, therefore, that Hillebrand's findings played some role in making more attractive to Panofsky and his contemporaries (cf. Jaensch, 1911) Hauck's contention linear perspective did not accord with subjection visual impressions. R. Peter's dissertation, *Studien über die Struktur* *des Sehramms* (1921) and cited by Panofsky (1921, 1927) was also significant in this context.

Before we leave this difficult question of sources it is well to remember that by the early twenties Einstein's discoveries had thrown into question the whole concept of space and its validity. Even the idea of perspective as a "symbolic form" was being seriously discussed prior to Panofsky's famous lecture. There was, for example, a fascinating book by W. Pollack, *Perspektive und Symbol in Philosophie und Rechtwissenschaf t* (1912) with a first chapter entitled "The perspectival and symbolic method in general". It explored the usefulness of perspective as an image to describe relative viewpoints in philosophy and in a lucid footnote (p. 11) acknowledged several other sources for this idea. Panofsky does not cite Pollack directly, but we do know that the book entered the Warburg library on 20th December, 1912. And just one year before Panofsky's lecture there appeared Spengler's influential *Decline of the West* (1923) which contained in its first volume a chapter on "the symbolism of the world view and the problem of space" which referred directly to questions of linear perspective. Spengler's second volume entitled "World Historical Perspectives" used the image strictly in its metaphorical sense. In the context of these examples the title to Panofsky's essay begins to emerge as a clarification of ideas that were "in the air". They also remind us that Panofsky's later analogies (1939, 1947) between changing theories of "technical" perspective and changing historical viewpoints expressed something more than a bad pun: they played on an idiom of the times. The immediate impact of *Die Perspektive...* may be gathered from reviews by Stern (1928), Schrade (1928), and Wieleitner (1928). Essays by Neri (1961) and Dalai (1961) have provided a general impression of how influential Panofsky's article became. Bazin (1968) has discussed the article's impact on concepts of space mentioning among others Buním (1940), White (1947, 1951, 1957), Francastel (1951), Parronchi (19[1]57; 1958, 1959, 1960) and Klein (1961), but ignoring entirely the important, albeit problematic, articles of Argan (1946) and Wittkower (1953) on the question of Brunelleschi's space, or the more recent work of Luporini (1964).

The question whether linear perspective is or is not a convention is perhaps the most significant issue that *Die Perspektive* has raised and here it is ironic that Panofsky, whose study of perspective was sparked by a passionate interest in the problem of accuracy and scientific certainty should have come to represent the view that linear perspective is merely a convention. There are two fairly obvious reasons why confusion should have arisen: 1) he never defined unequivocally just how linear perspective related to the visual process; 2) he wavered between using "perspective" a) loosely to define various methods of spatial representation and b) strictly in the sense of "linear perspective", which he never doubted was the only method obeying the strict laws of mathematical space (cf. 1927, his definitions on pp. 258 and pp. 268).

It was the physiologist Pirenne (1952), who first became disturbed by the writings of Panofsky (1927), Bunim (1940), White (1949, 1951) and Pope-Hennessy (1950) which all intimated perspective was a convention, and he therefore set out to establish the "scientific basis" of linear perspective. In a private discussion Pirenne "converted" Gombrich who then (1956) proceeded to refute Read's (1956) claim perspective was merely a convention. Others soon entered the debate. Gioseffi (1957, 1965), Previtali (1961), Doesschate (1964) sided clearly with Pirenne and Gombrich. Meanwhile White (1957) remained a prime defender of the idea of perspective as a convention. Goodman (1969) brought the debate into the camp of philosophy and described himself as joining ranks with Panofsky and Arnheim contra Pirenne, Gibson and Gombrich. In an important work Pirenne (1970) reviewed highlights of the debate and made (p. 93) "an attempt at a restatement of the whole problem". Challenged by Goodman's statement (1969) Gombrich (1972) called for a distinction between the "What" and the "How" of vision. Hansen (1973) attacked Gombrich and re-asserted the convention theory. Gombrich (1974) in an attempt to further clarify the issue answered Hansen by suggesting the debate had arisen from (p. 146) "a confusion of the mirror with the map" theories of visual representation. Thus Panofsky's historical essay has had the surprising effect of inspiring new work on the psychological, physiological and even philosophical aspects of perspective and indeed visual perception generally.

To give some idea of the enormous impact *Die Perspektive* has had on art historians we shall begin by simply outlining five debates it has stimulated:

1) Was linear perspective known in Antiquity? Panofsky claimed no. The majority of recent scholarship including Richter's (1970) through work has supported this claim. Notable exceptions are White (1957) and Gioseffi (1957, 1965).

2) Did the Ancients develop a curvilinear method of perspective? Panofsky tentatively proposed this idea that immediately inspired a round of debate which Bunim (1940) has conveniently summarized. Beyen (1939) put forth a modified theory which Little (1971) has since accepted. Richter (1970) believes there is no evidence to prove the Ancients had any systematic method.

3) Was the distance point construction known to fifteenth century Italy? Panofsky claimed no. This has since been questioned by Spencer (1960, p. 226), Maltese (1967, p. 140) Carter (1970, p. 852). For fuller discussion of the problems involved see Brion-Guerry (1962), Kitao (1962, pp. 192-94) and Edgerton (1966, p. 367 footnote 2). We should add that Klein (1962) argued strongly the method was known in 15th century Italy, but this was attacked by Parronchi (1962) and later discussed by Edgerton (1966).

4) What was Alberti's method? Panofsky was the first to claim (1915 and 1927) it was basically a *costruzione legittima* method. Edgerton (1966) has conveniently summarized how recent studies have, with some modifications, continued to uphold this interpretation.

5) What was Pomponius Gauricus' method? Panofsky claimed it was effectively the same as Alberti's *costruzione legittima*. This has since been amended by Gioseffi (1957, pp. 89-93), and again by Klein (1961, pp. 218 ff.) and discussed by Kitao (1962, pp. 192-94).

Turning to a more general plane it is worth noting how Panofsky's influence has changed over the past half century. When Schrade (1928, p. 577) reviewed *Die Perspektive*, he hailed it for showing the mediaeval origins of linear perspective. Since then both historians of science, notably Santillana (1959) and historians of art, especially Argan (1946) and Wittkower (1953) have re-interpreted Panofsky to focus on Brunelleschi as the inventor of an entirely new technique. Moreover, Panofsky himself appears to have encouraged Krautheimer (1956) in this direction with the result there is now a tendency to assume that even the early fifteenth century possessed highly abstract concepts of space and, notwithstanding White (1957) the mediaeval origins tend to be played down.

At the same time there have been developments which have brought to light the limitations of Panofsky's approach to perspective. We shall mention four: 1) Schapiro (1953, p. 110) questioned whether representations of "space" were a valid tool for cultural history; 2) Ehrenzweig (1953, p. 181) claimed linear perspective was "not a cooly rational archievement" and "served in its first place to express an irrational symbolism"; 3) Gibson (1966, p. 238) challenged whether "space" was even a meaningful term; 4) Gombrich (1972a) replying to Gíbson (1971) began to explore more deeply subjective aspects in perception of "perspective" representation. More recent work by Gombrich (1972, 1974) and indeed Johansson (1975) has emphasized an important role for psychology in the future study of perspective. Bullough's work on "psychical distance" (1959) may be seen as another indication of a trend away from Panofsky's equation of perspective with strict objectivity and scientific accuracy.

While scholars have devoted much energy to challenging Panofsky on details of interpretation few questions have been raised concerning the fundamental issues implicit in his work. For the present it may suffice if we draw attention to four of these 1) the value of the distinction between "angle axion" and "distance axiom"; 2) the viability of an *a priori* framework of explanation; 3) the connection between theories of vision and representation and 4) the question of curvilinear perspective.

1) However attractive is Panofsky's opposition between an "angle axiom" in Antiquity and a "distance axiom" in the Renaissance it immediately begs embarrassing questions: Were not the Greeks interested in distance? Did not Aristarchus (c. 310-230 B. C.) write *On the Sizes and Distances o f the Moon?* Is not the inverse relation of size to distance implicit in the surveying propositions (19-21) of Euclid's *Optics*?

If we ponder the matter a little we realize that the "angle axiom" and the "distance axiom" are both concerned with "distance", but tacitly assume different definitions for the same term. To clarify this it will help if we revert to some simple line drawings. Common sense tells us that something further away appears smaller. Strictly speaking

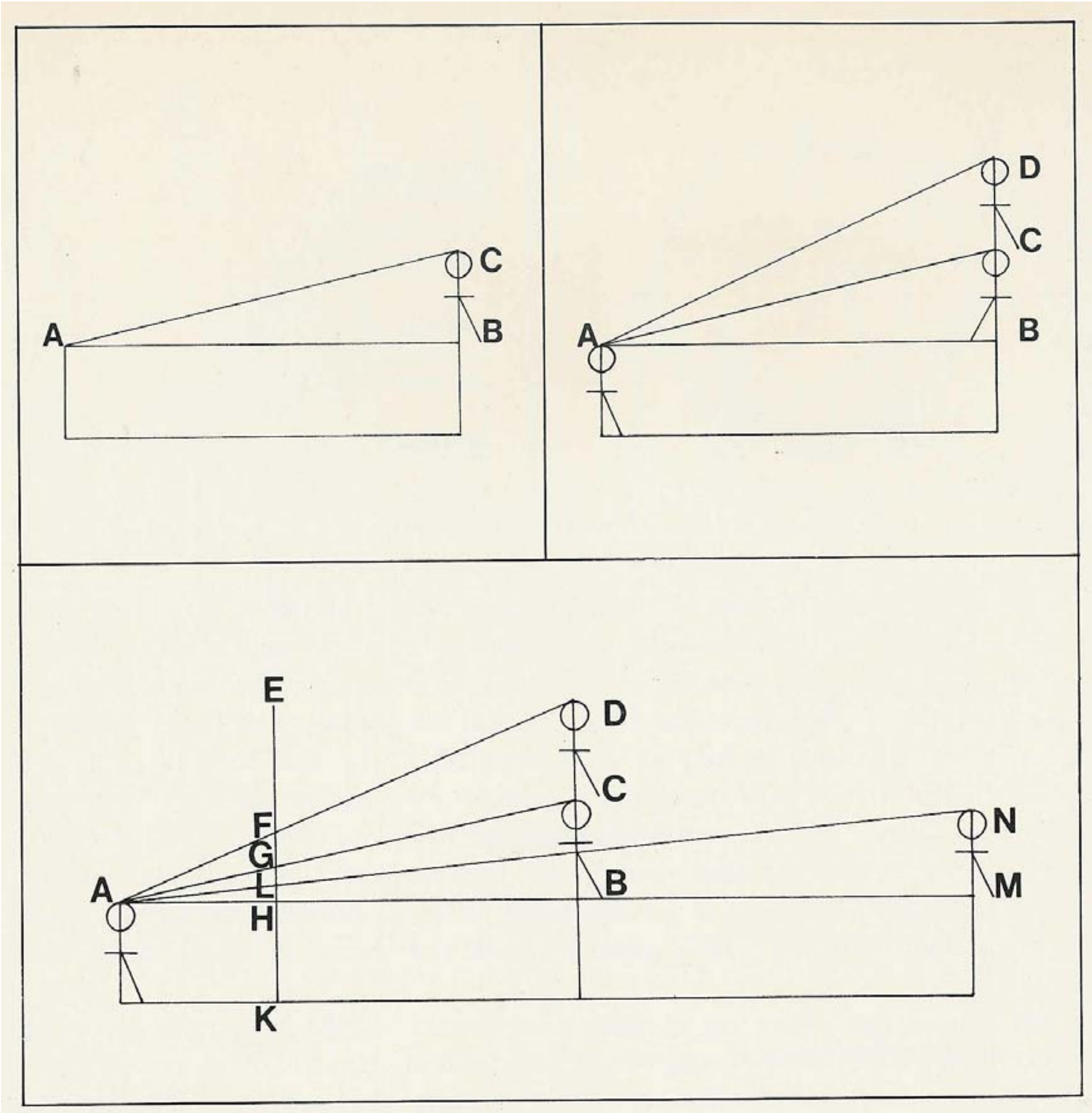


Figure 1. Common sense distance in its extreme form implies that when a figure at A looks at figure BC those parts of the figure that are nearer C will appear smaller (because AC is more distant than AB).

Figure 2a. According to the Euclidean visual angles theory the person at A will see the figure CD as smaller tFian the person at BC because -<CAD is smaller then < BAC.

Figure 2b. According to linear perspective the person at A will not see the figure CD as smaller than the person at BC because projected size and not angular size on an interposed plane is the determining factor. Hence figure BC is seen as equal to figure CD because HG=GF on the vertical (glass) plane EK. Figure NM on the other hand appears smaller than BC because his projected size is smaller (i.e. HL is smaller than GH).

(fig. 1) this means that if a viewer at a looks at a man BC those parts closer to C will appear smaller because AC is further than AB. Euclid recognized we do not normally see persons as "shrinking" and thus put forth the simple but brilliant suggestion that whatever is seen under the same visual angle is seen as being constant. (Euclid did not define however what the size of the angle should be). Thus within the limits of angle BAC one can ignore the fact AC is further than AB.

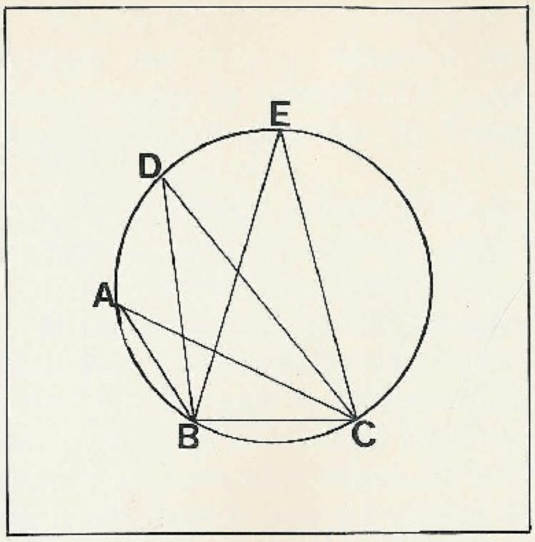
Now suppose there was (fig. 2 a) a second person standing directly above BC. Euclid claimed he would appear smaller. Why? Because <DAC is smaller than <CAB. Why is the angle smaller? Because CD is obviously further away from A than BC.

We can safely term Euclid's explanation as the basically common sense definition of distance. Its most important characteristic is it makes no distinction between the effects of distance in any given direction. Hence according to this view, if an object be moved upward or shifted off to the side or simply backwards, it is all the same. Distance is distance and that's that.

The Euclidean explanation may sound too obvious to need repeating until we realize it contradicts the principles of linear perspective. Let us return (fig. 2b) to our two men, BC and CD. Linear perspective involves, we are told, interposing a plane, say EFGHK between the viewer and the "objects" to be drawn. In which case BC is "projected" as HG and CD is "projected" as GF.

Moreover FG=GH which means perspective drawing *ignores* the fact CD is higher than BC. Now imagine that our fig. 2b represents a bird's eye view and we are looking at two objects BC and CD stretched o$ to the side of A. Their projected size is still the same, which shows perspective also *ignores* the fact CD is further o$ to the side than BC. On the other hand, if we now imagine a person standing at MN we note his "projected size" HL is considerably smaller than HG (which is the "projected size" of BC). In other words the inverse size/distance relationship which Panofsky stressed as fundamental to linear perspective applies only to what we might call "level distance" and not "vertical" or "lateral" distance. This distinction clears up at least two points. a) We can now see why Goodman (1969) was wrong when he claimed (p. 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" the poles should also be drawn converging.



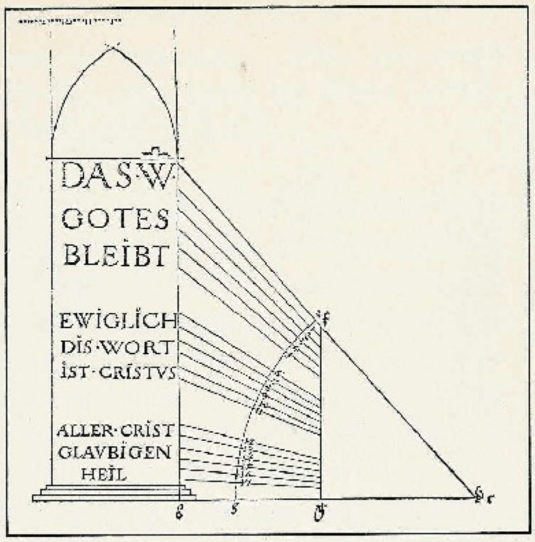
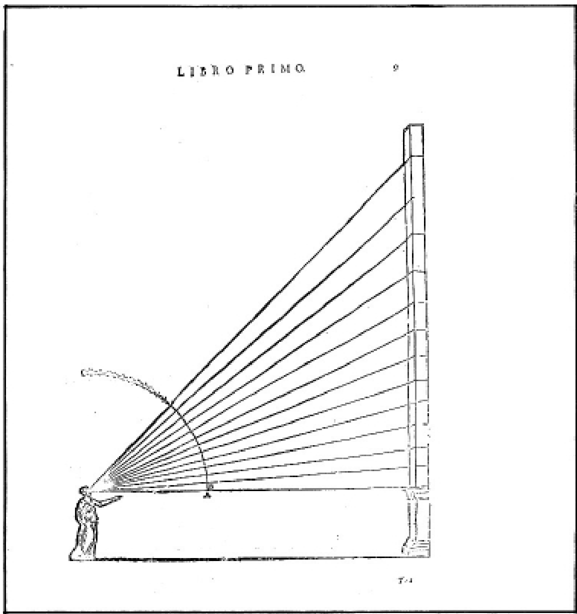


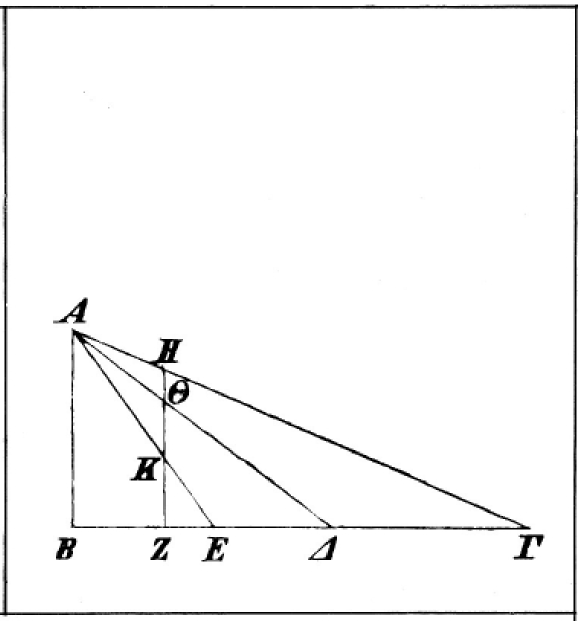
Figure 3. Here a paradox of the Euclidean visual angles theory is shown namely that â concern for angles leads one to deny any strict relation between angulâr size and distance. Points A, D, and E are variously removed from BC, yet <BAC = <BDC = <BEC.

Figure 4. An adaptation of the Euclidean visual angles principle in Dürer's *Under-weysung der Messung*.

For it was actually his common sense view of "distance" and not, as he thought, the laws of geometry, that "contradicted" linear perspective. b) We are now in a position to understand why Panofsky's distinction between "angle" and "distance" axioms is misleading. For we realize that the real stumbling block in arriving at linear perspective lay not in a lack of interest in distance, but rather in a failure to distinguish between different kinds of distance. Common sense was, and still remains, a problem standing in the way of linear perspective. In which case Panofsky's question can be restated. Instead of asking how and why did an interest in "distance" originate we should ask how and why did persons come to realize there are different "kinds" of distance and discover that "distance" and "common sense" views are not necessarily connected?

2) Our second problem concerning Panefsky's a *priori* framework of explanation requires that we explore briefly Euclid's concept of angular size. If we think about it as much as Euclid did (cf. *Optics,* prop. 38) we come across situations in which we notice (fig. 3) <BAC = < BDC = <BEC albeit E is obviously "further away" from BC than is A. The implication is that common sense notions of distance involve a) a committment to visual angles principles which, in turn, involves b) moving away from a commitment to strict inverse relations between size/ distance and requires c) that we rely instead on ratio and proportion as a means of explanation. And since proportion involves relations within a totality this, in turn, implies d) a finite framework of explanation.





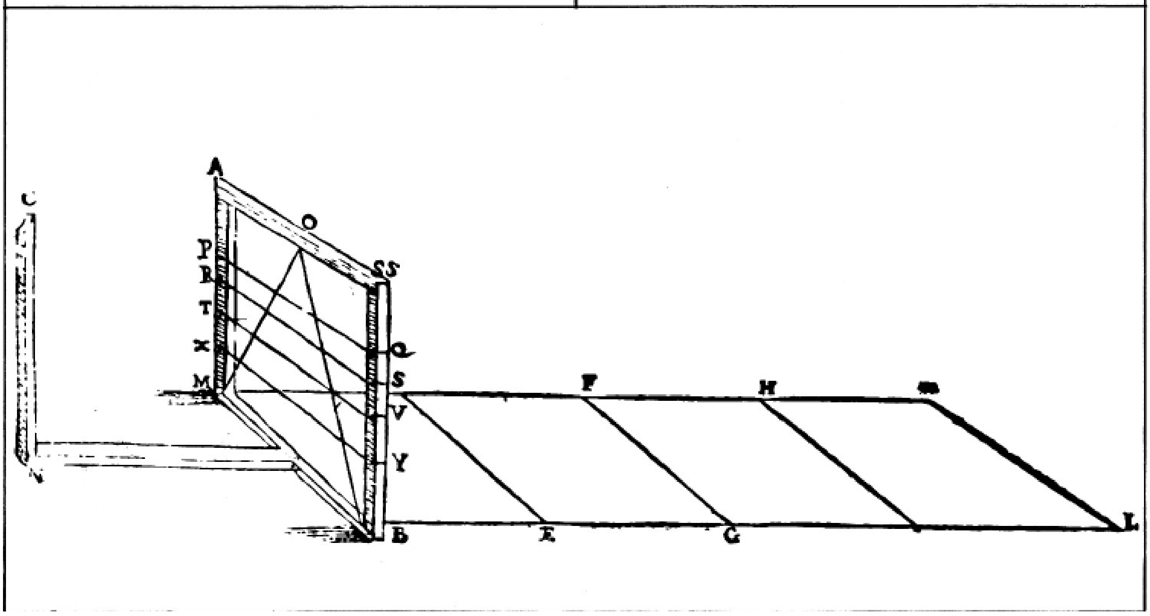


Figure 5. Another adaptation of the Euclidean visual angles principle in Serlio's treatise on architecture (vol. I).

Figure 6. Figure illustrating Euclid's theorem 10 in the *Optics*, that things further away appear higher on the interposed rod or plane.

Figure 7. G. Tommaso Laureti's instrument demonstrating the basic principles of linear perspective. When a person stands at C the parallels MK and BL will converge towards a vanishing point O which is always at the height of the eye. It is likely that this instrument was based on one of Leonardo's demonstrations and not unlikely that this was the Bolognese scholar from whom Dürer learned about perspective and obtained ideas about his own "Dürer window".

In other words, common sense notions of distance have at least two paradoxical implications: a) they work against a committment to measured distance; b) they engender at the same time a finite world view via their recourse to proportion and ratio as modes of explanation. Panofsky argued the opposite, namely, that a finite world view, required "aggregate space", which precluded an interest in distance and demanded an "angle axiom". But is it not likely the truth lies in a reciprocal view and that common sense notions of distance generated a finite world view at least as much as vice-versa?

3) Panofsky's neo-Kantian framework tempted him to believe theories of vision and representation must necessarily correspond such that when one changes, the other is modified accordingly. Unfortunately the story is not so simple. The invention of linear perspective did not change the Euclidean theory of angular size in the 16th century. Indeed, even in the 1650's when Bosse became involved in a heated debate with the Academy to demonstrate the tensions which continued to exist between Euclidean optics (with its notions of angular size), and linear perspective (with its concept of projected size), the result was the general acceptance of a more loosely defined concept of perspective which allowed optical adjustments methods. So even in the latter 17th century Euclid's theory of vision was not revised to accord with linear perspective.

The problem with Panofsky's approach is that it requires overlooking entirely the tensions (which continued throughout the Renaissance) among a) what is rhetorically asserted; b) what is theoretically claimed and/or demonstrated and c) what is practically achieved. For example, throughout the 16th century one finds repeated assertions that what is seen is what is drawn is what is there. In short, there exists a rhetoric that asserts a one to one correspondece between vision, representation and the measured world.

But at the same time both theory and practice contradict this (cf. Doesschate, 1964, pp. 39-43). Sixteenth century perspective texts tend to resstrict demonstrations of linear perspective to level distance. Tommaso Laureti's famous instrument (fig. 6) is perhaps the clearest concrete example. But this means the effects of linear perspective are discussed primarily in the area below eye level. In the areas above eye level perspective authors such as Serlio (1545, etc.) (fig. 5) and Romano (1595) tend to follow Dürer's (fig. 7) restatement of the visual angles principle. In other words a theoretical tension evolves between visual angles principles above eye level and linear perspective below eye level. An alternative version - cf. Barbaro (1568) - applies linear perspective to context (i. e. buildings, pavement etc.) and pretends that visual angles principles are applicable only to individual objects within that context. On the level of practice things are different again and there are any number of combinations and compromises.

Which leads us to suggest that if the questions Panofsky raised concerning links between vision, representation and the measured world are to be meaningfully pursued, a method will be needed to distinguish among these different levels. Perhaps further study would reveal that a given "culture" tended to concentrate on a) rhetorical assertion, whereas another "culture" became preoccupied with b) theoretical demonstration, while a third became concerned with eradicating, say, contradictions between a and b.

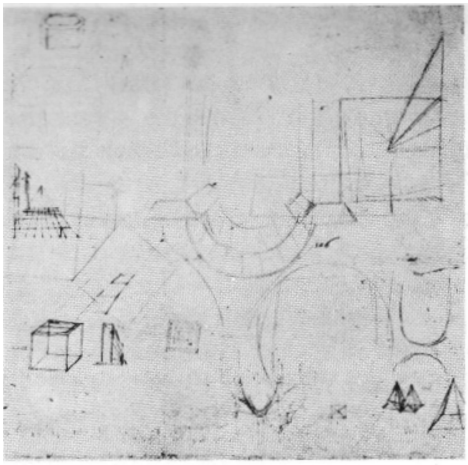
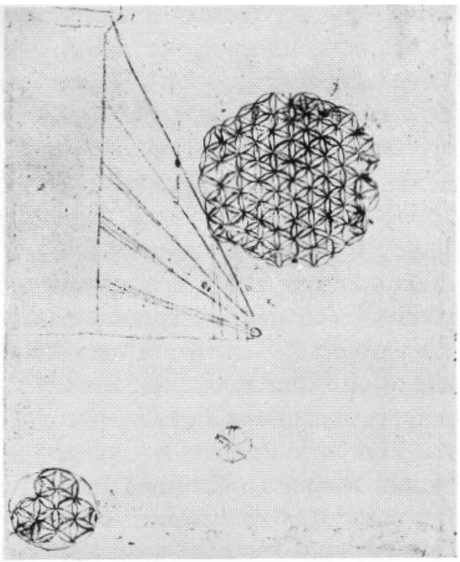
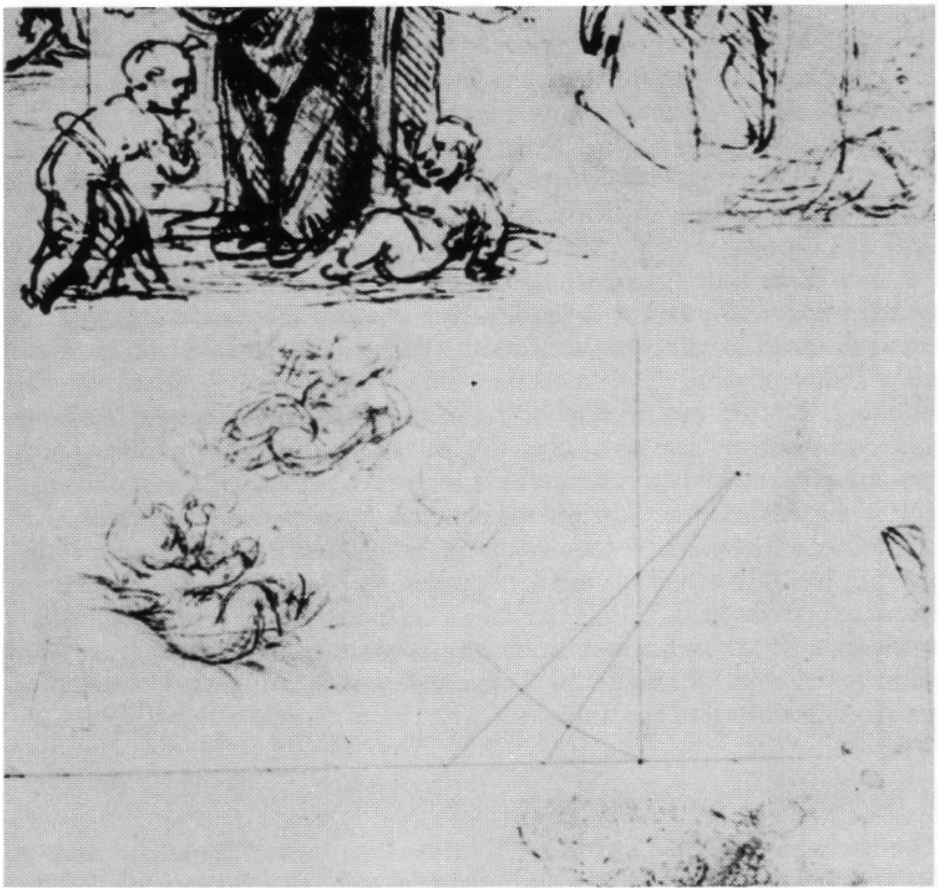
4) Pirenne (1952, 1970) has established that Panofsky was wrong in his assumptions about physiological optics in assuming a concave projection plane, imitating the shape of the retina, better recorded the subjective appearance of vision. Continuing on purely technical grounds we might ask a) why Panofsky uses a convex projection plane when he claims he is imitating a retina or b) how a projection of straight lines onto a curved surface can result in straight lines? On this matter it is easy to dismiss Panofsky's solution on technical grounds. But how then are we to explain the example of "curvilinear perspective" revealed not only in the *Codex Huygens* but also, as Pedretti (1963) has claimed, in Leonardo himself? Perhaps the crucial step is to forget entirely the retina analogy and consider other explanations.

The final sentence of the text accompanying the tenth proposition of Euclid's *Optics* states: "It is obvious also that planes situated higher up will appear concave". Ver Eecke, the translator of the French edition (1959) comments that "this corollary, as it is expressed, makes no sense". But if we turn to Witelo, the twelfth century Polish writer on optics, we discover a fascinating transformation of Euclid's proposition (IV: 37): And it follows from this that with the eye raised many a surface of a plane far from the eye will appear concave, for the forms of such points tend to the eye by means of a circumference around the centre of sight because of the equality of the visual power.

Even though the accompanying diagram (fig. 7) does not show it, we now realize that the curve mentioned defines equal "distances" from the eye and is, quite semply, another expression of a common sense notion of distance (this time applied to intensity of visual power).

If we now turn to one of the earliest diagrams (fig. 10) in Leonardo (c. 1483) showing this curved line we are at once struck a) how it uses the diagram from Euclid's proposition 10 (cf. fig. 7) as its starting point and b) how it clearly illustrates what Witelo had merely described.

This obviously throws a very different light on debates concerning the use of curvilinear and so-called "synthetic" (cf. White 1949, 1951, 1957) perspective in the Renaissance, for its makes us aware that what bothered Leonardo and the author of the *Codex Huygens* had little to do with retinal shape: it stemmed instead from an ongoing bewilderment about the paradoxes of distance. They knew "common sense" notions of distance were vital for Euclidean optics. They also knew that "distance" somehow continued to play an essential role in linear perspective but they were not, as yet, quite clear about its involving only one kind of distance. Hence, Leonardo's drawing shows in a way a confrontation of the old "common sense" notions of distance, with the new and not yet fully understood "level distance" of linear perspective.

Figures 8, 9. Two further figures from the *Codex Atlanticus,* fol. 44r, 44v (new edition), again without accompanying text, relating to Euclidean visual angles problems;
Figure 10. An optical diagram relating to the visual angles problem in Leonardo's *Studies for a Virgin adoring the infant Christ,* ca. 1483, now in the Metropolitan Museum of Art, New York.

There obviously exist many further examples we cannot discuss here, but we should perhaps just mention how this "curve" we have identified relates also to problems scholars have tended to associate with anamorphosis -cf. Baltrusaitis (1969). In a hitherto undiscussed diagram (fig. 10) of the *Codex Atlanticus* (1973, II, 43 r) we find Leonardo applying the equal distance curve to the area above the eye, almost as if he were illustrating that puzzling final line of Euclid's propostion 10. When we find him, a few pages later, (figg. 8, 9) returning to these themes (fol. 44r, 44v) we suddenly realize a) how this relates to the diagram Dürer made famous and b) why it was natural for perspective texts to include such diagrams. Optical adjustments methods involving common sense notions of distance could only be excluded once thinkers had accepted that linear perspective did not always involve "common sense". We might readily go on, but perhaps it is fitting our (re)-assestment of the great Panofsky's work should end with this example showing new links between Leonardo and Dürer, thus affirming the theme that initiated his own quest: Dürer's indebtedness to the Italians.

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