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Space, Time and Perspective in Print Culture and Electronic Media

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1. Introduction

Linear perspective and print culture are two key developments associated with the Renaissance. While separate studies of each topic abound, relatively little attention has been given to connections between them. This essay opens with a review of literature on these connections. A fresh look at the evidence of painting practice and treatises leads to a reassessment of earlier premises and conclusions. It is claimed that perspective is not simply a Renaissance phenomenon; that its temporal and kinetic dimensions actually require electronic media; that these have basic implications for our concepts of knowledge and that a new era in the understanding of perspective is therefore about to begin.

2. Standard Claims

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:

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.¹

Ivins served as a starting point for Marshall McLuhan's more dramatic claims in the *Gutenberg Galaxy* (1962): "primitive drawing is two dimensional, whereas the drawing and painting of literate man tends towards perspective".² McLuhan remained unclear concerning the precise relationship between perspective and printing. On the one hand he argued that: "the sheer increase in the quantity of information movement favoured the visual organization of knowledge and the rise of perspective even before typography".³ On the other hand he suggested that typography was actually a prerequisite for perspective:

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.⁴

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 visual;⁵ between acoustic space and visual space⁶; or between the audile/tactile and the visual.⁷ Acoustic space was linked with the two dimensional⁸: 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 logical.⁹ McLuhan related this to changing emphases on the *trivium*.¹⁰ Acoustic space thus became linked with rhetoric, visual space with dialectic (i.e.logic).¹¹ 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 logical.¹² 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 effect.¹³

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 villain.¹⁴ 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.

McLuhan was not well understood. Professor Elizabeth Eisenstein, in *The Printing Press as an Agent of Change*, saw McLuhan's claims as an incautious version¹⁵ McLuhan's arguments are actually fully independent of Panofsky's claims. 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: "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."¹⁶

According to Panofsky the development of perspective went hand in hand with the rise of modern science. This Professor Eisenstein challenged also: "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."¹⁷ Aside from these criticisms, passing comments on treatises by Alberti¹⁸, Piero della Francesca,¹⁹ Dürer,²⁰ Jamnitzer²¹ and a few general references,²² Eisenstein did not explore connections between perspective and printing.

Meanwhile, other connections between perspective, texts and printing culture were suggested. Sir Ernst Gombrich, in *Art and Illusion*, emphasized the connection between narrative and the development of perspectival representation²³ (mimesis, illusionism). More recently in *Means and Ends* 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."²⁴ He also acknowledged that "the conquest of perspective and of anatomy play their part in this story".²⁵ By implication there was a direct relationship between the re-interpretation of biblical texts and the development of perspective. The evidence of painting practice suggests a more complex story than any of the above explanations.

3. Painting Practice

High Mediaeval (1100-1399)

In the eleventh century the stabilization of the West after the barbarian hordes, and the safe entry into a new millenium brought 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 objects.

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, 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 Caiphaz 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 uses the same technique in the Scrovegni Chapel in Padua (1304-1304), where an oblique view of an open fronted house serves for both the *Annunciation to St. Anne* and the *Birth of the Virgin*, and where a temple with a niche serves as a continuation between three scenes: *Ceremony of the Rods*, *Prayer for the Miracle of the Rods* and *Marriage of the Virgin*. This function of relating separate scenes in a complex narrative explains why a few proto-perspectival elements become stock images which improve empirically, while other architectural elements remain spatially awkward and unconvincing. Piero della Francesca takes up these stock images in his *De prospectiva pingendi* (c.1480). Barbaro publishes them in his *Pratica della prospettiva* (1568) and thereafter they become familiar elements in the printed texts. Hence the early manuscripts and printed texts (1450-1550) on perspective consolidate and present in mathematical terms images that the tradition of painting practice had mastered empirically in the two previous centuries. Their initial role is to standardize rather than to innovate. Meanwhile artists explore the practical potentials of perspective. Paolo Uccello in his *Profanation of the Host* uses 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.

If scenes with different vanishing points are implicitly related by means of perspective, scenes physically separated from one another are 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--develop this idea in their *Annunciation* in San Clemente, and Foppa uses it dramatically in his *Annunciation* in S. Eustorgio. This applies equally to other themes. Parronchi has suggested that Ghiberti used it on the doors of the *Baptistry* in Florence²⁶ 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, Santa Croce, 1426-1427).²⁷ More subtle variants are also possible: spatially analogous scenes can 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.

Professor Aronberg Lavin's research into the history of narrative painting has brought to light an unusual feature in their arrangement: the narratives do not follow any single, simple sequence from left to right analogous to the sequence of letters on a page. Instead they criss-cross, zig-zag and follow other unexpected patterns. Nor does 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 become 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 changes as literacy becomes 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 are 22 in Germany alone before Luther). Artists are increasingly able to take for granted that their viewers have read the biblical stories or at least have heard them read or discussed.

Secondly, the situation is complicated through an increased concern with systematic typological and symbolic presentation. In the great rose windows of the 13th century (e.g., Chartres, Paris, York) the emphasis is 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 gains in significance to the point that Raphael's task in the *Stanze* becomes one of finding parallels between Christian and Antique themes: the Church fathers vs. the School of Athens. In the great cycles it is no longer a question of telling complete stories, but rather one of choosing key episodes in stories which can be balanced by others. Because perspective provides a framework for the organization and comprehension of such scenes, their narrative order often becomes less significant.

There is yet a third complicating factor. Early proto-perspectival elements function partly as frames separating one scene from another. In the Scrovegni Chapel in Padua, Giotto explores how this framing function can be manipulated in order to create ambiguities between real and fictive spaces. Sandström²⁸ has made a perceptive study of these developments. They are of interest for our purposes because the resulting ambiguities increase the potential for polyvalent readings of the scenes theoretically linked and

systematically related: for this reason the Sistine Chapel is more complex than the Scrovegni Chapel.

In the 1470's, artists begin to play with relating different viewpoints within a single painting. Piero della Francesca's *Brera Altarpiece* (Milan, Brera, 1472-1474) is a case in point. One views it frontally to see the context generally and then looks at it from the bottom left in order to recognize that what appeared to be an egg is actually a sphere. Holbein uses the same principle in his *Ambassadors* (London, National Gallery) and Maignan develops it dramatically in his *Saint Francis de Paul* in S. Trinità in Monte. The development of such anamorphic games²⁹ further subverts the linear sequence of stories. Sometimes, perspective which developed in the context of narrative, transforms its sequence, and reduces what had been a flowing story into balanced oppositions of key scenes.

Emphasizing Scenes

This is partly because perspective not only relates scenes but also emphasizes 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 proves inconvenient for a Christian tradition that focusses on Christ, Mary and various saints. A compromise thus ensues. Individual figures continue to dominate the main panels, while scenes relating to their lives are relegated to the predellas where key scenes are emphasized through perspectival effects. In the life of Christ these are usually the *Annunciation*, *Flagellation* and *Last Supper*.

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.³⁰ 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. If Renaissance artists did not discuss the problem, they were clearly aware of it. Michael Kubovy has termed this phenomenon *robustness* of perspective,³¹ 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.³²

In the *Last Supper* perspective emphasizes the painting precisely because it can be viewed without undue distortion from anywhere within the refectory of Santa Maria delle Grazie. The same holds 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 can be large as in Masolino's version of Herod's palace at Castiglione d'Olona³³ or small as in Piero della Francesca's *Brera Altar*, but the effects are the same. And like the relating function, the

emphasizing function of perspective undermines 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*, has 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.”³⁴

For art, the implications of literacy are equally important.³⁵ In pre-literate societies a statue of a given god, insomuch it is often the central object that the members of a tribe have in common, defines the communality of a group. Variation is very limited because deviation from the norm can result in lack of recognition. This changes with the advent of literacy. Characteristics of a given god, or the Diety, are known from texts, and because texts now define what persons know and have in common, it is no longer necessary for the work of art to establish a sense of communality. Indeed the challenge arises of creating variants on already well known themes. If this is true for the *Bible* in general, it is particularly so for key scenes such as the *Annunciation*. Proto-perspectival features augment this process of variation even before the rules of perspective are 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.³⁶

After Alberti's first treatise (1434), and particularly after the advent of printing in the 1450's, the process of variation increases in intensity. Some examples, such as the unknown fifteenth century painter in Santa Maria Novella continue to produce rough empirical versions. Fra Angelico makes 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 explores. Sometimes the scene is inside on a regular pavement as in the anonymous *Annunciation* in the Gardner Collection; outside on such a pavement, as in the version by Francesco di Giorgio and Naroccio di Landini in the 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, develops a spatial example from Bellini's *Sketchbook* in his *Annunciation* (London, National Gallery), which is 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 combines information from a biblical text, a sketchbook and an historical event in his painting. More complex textual sources call 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 develops recognizable variants of the same subject. Flemish versions are normally in living rooms (e.g. Robert Campin's version in the Metropolitan), bedrooms (e.g. Gerard David in the Städlesches in Frankfurt) or in apses of churches as in Van Eyck's version (Berlin, Staatliche Museen), which is adapted by the Master of Bruges (Antwerp, Koninklijk Museum voor Schone Kunsten, 1499). In Germany, *Annunciations* are also frequently in bedrooms as in Dürer's woodcut (e.g. San Marino, Huntington Library, 1502) and churches as in Grünewald's *Isenheim Altar* (Colmar, Musée d'Unterlinden, 1510-1515), but with very different uses of space. Meanwhile, other Flemish versions combine 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 become popular in Spain, as witnessed by Alejo Fernandez' version (Seville, Museo de Bellas Artes) or in Berrequete's *Annunciation* (Burgos, Cartuja de Miraflores).

This practical tradition of using perspective to produce unexpected variants of an already familiar theme continues into the seventeenth century. For instance, nine of Saenredam's 18 surviving construction drawings for his famous interiors involves a single church, St. Bavo,³⁷ in Haarlem, the exterior of which contemporaries such as Berckheyde also depict from different points of view.

Examples such as the *Bayeux Tapestry* remind us that already in the eleventh century 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, in an important dissertation,³⁸ has convincingly shown 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 occurs through gradual mastery of a surprisingly small number of basic forms in the context of a few stock scenes. Perspectival effects thus begin long before the advent of printing. Nor are these effects necessarily linear. As we have shown they often undermine the strict sequence of the storytelling. Spatial harmony now begins to vie with symbolic harmony. In terms of contents both faith and reason are represented: i.e., mainly Christian and some pagan elements.

Renaissance (1400-1500)

Further experience gradually leads artists to master these proto-perspectival elements and discover, a) practical solutions in terms of vanishing points (Lorenzetti, 1344), b) practical demonstrations (Brunelleschi, c.1415-1425) and, c) quantitative experimental demonstrations (Leonardo, 1492) and recognize that such perspectival elements emphasize scenes and offer new possibilities in varying them. Spatial harmony now outweighs symbolic harmony. The key developments in these new explorations take place in Florence in chapels such as the Brancacci in Santa Croce; in Santa Maria della

Novella and the Chiesa del Carmine. With respect to contents faith and reason are treated increasingly on equal terms.

High Renaissance (1500-1527)

These principles are 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 determines symbolic harmony and gives 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 Rencascences*. There is a continuity between St. Michael's, Hildesheim and the Sistine Chapel. What sets them apart is that organization in the first 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 second is dominated by spatial harmonies, allowing a much more complex interplay of related themes with greater emphasis and variation. Raphael develops these potentials in the *Stanze*, maintaining the assumption that the frame remains the key to spatial harmony. But in terms of contents Christian and pagan elements vie with one another: faith is being challenged by reason.

Mannerism (1527-1600)

Mannerism questions this assumption that a frame is 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 are thus abandoned as, for instance, in Giulio Romano's rooms for the Giants in the Palazzo del Te. In terms of contents, faith and reason are now often in conflict. Meanwhile the spread of printed picture books with perspectival examples create new ambiguities between ancient and modern, ideal and real buildings, provoking new combinations which radically expand the horizons of the imagination. By this time the combination of perspective and print culture ushers in a revolution.

Baroque (1600-1750)

These mannerist experiments reveal increasing ambiguities between the spaces of 1) pictures inside the frames; 2) the frame itself; 3) areas beyond the frames. This leads to such a conscious play with the boundaries between painted and architectural surfaces and spaces that it becomes impossible to distinguish them. The manipulation of depicted space thus becomes combined in a larger programme involving the manipulation of architectural and ultimately environmental space. This transforms 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 are 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 are for a brief period combined in a coherent spatial harmony. When this harmony is subsequently challenged by the mannerists and ultimately rejected by baroque artists, the actual content of the stories gradually loses significance. A method which had promised to give new form to narrative content, now threatens to replace content by new spatial forms.

4. Printed Treatises

The evidence of the treatises is also more complex than usually imagined. The first treatises on the subject in the fifteenth century, consolidate shapes already mastered in practice. The treatises introduce no new spatial scenes until the 1540's. Even in the seventeenth century the gradual conquest of reality continues largely in the domain of painting practice with individuals such as Saenredam.³⁹ Although Eisenstein argued that the advent of printing involved a sudden revolution,⁴⁰ in the case of perspectival treatises it is necessary to stress the gradual nature of the process. The first treatise by Alberti is in 1434. The first published treatise is a short seven page section in Luca Pacioli's *Summa* of 1494. After 1500 the production of printed treatises increases steadily⁴¹ (fig. 1). Production clearly does not end with the Renaissance.

The advent of printing brings no sudden dissemination of knowledge throughout the whole of Europe. Crossing of boundaries in the early period is due more to the travels of key individuals: Dürer and Pacher come to Italy from Germany; Heemskerck and Cock come from the Low Countries; Jean Fouquet, René d'Anjou, Jean Pélerin and Androuet du Cerceau come from France. By the 1540's the near simultaneous appearance of Serlio in Italian (Venice), French (Paris), and Dutch (Antwerp), heralds an international dimension of printing which had thus far remained implicit. With the publication of Marolois' works in Latin, German, French and Dutch (1604-1605) the idea of multilingual editions of technical writings is established, and in the next generation the works of Desargues and Bosse spread across the whole of Europe in these languages. Hence printing revolutionizes the spread of perspective, but much more gradually than is frequently assumed.

Contents

In considering the contents of these printed treatises in the period 1500-1700 it is important to stress their great variety. Some deal only fleetingly with perspective in the context of a larger work; e.g., Dürer in a work on geometry and the most popular author on perspective in the sixteenth century, Serlio, in a work on architecture. Some treatises, e.g. Gauricus, have no illustrations.

Date	Treatises Published
1401-1500	0
1501-1600	140
1601-1700	370
1701-1800	1600

1801-1900	2000
1901-1990	2500

Fig. 1. Printed treatises since 1400

Others by Androuet du Cerceau or Vredeman de Vries consist almost solely of pictures. Between these extremes there are treatises covering a variety of topics, the precise order and emphasis of which changes with every title and most editions. Keeping these provisos in mind, it is useful to examine briefly each of the main themes, namely: theoretical foundations, instruments and practical examples, including objects, buildings, environments and plays between reality and fiction.

Theoretical Foundations

Historically, linear perspective was linked with the Latin term for optics (*perspectiva*) and, as a result, introductory sections of treatises (e.g., Barbaro, 1568; Danti, 1583) frequently pay lip service to Euclid's *Optics*. Since late antiquity, the study of optics included the branches of catoptrics and scenography. Hence perspective treatises often include a section on reflection involving both mirrors and water. Partly due to an etymological confusion between *scaenographia* and *sciagraphia*, shadows also become a standard topic in perspective treatises.

Meanwhile, Leonardo's quantitative perspectival experiments bring to light contradictions between Euclid's optical theories and linear perspective.⁴² Sixteenth century authors rely increasingly on Euclid's *Elements* as a foundation. In Urbino, there are Federico Commandino and his student Guidobaldo del Monte, who also explore connections between perspective and conic sections. In Paris, Aleaume, Migon, Desargues and Pascal pursue these connections, and perspective emerges as a basic branch of mathematics until, in the early nineteenth century, it is subsumed as part of descriptive geometry. If the scientific principles of perspective are thereby established, another factor combines to make them more generally comprehensible.

Instruments

From the time of Brunelleschi and Alberti, perspective is associated with a practical instrument known as a perspectival window or veil (*velo, pariete*). Leonardo makes the first recorded drawing thereof and also explores the properties of camera obscuras. Sixteenth century authors establish both theoretical and practical connections among perspective, planispheres, astrolabes, analemmas and sundials, as well as a variety of universal surveying instruments. At the turn of the seventeenth century the proportional compass and sector also become connected with perspective. The same individuals (e.g., Commandino, Guidobaldo del Monte, Galileo, Desargues) responsible for these instruments are also at the frontiers of mathematics and science, leading to new interplay of theory and practice and a greater emphasis on visual demonstration.

As early as 1480, Piero della Francesca discusses two alternative methods of perspective. After Danti's edition of Vignola (1583), these are referred to as the two rules. Of these, one method based on the perspectival window, becomes known as the legitimate construction, while a second, initially based on geometrical principles of proportional diminution becomes known as the distance point construction.⁴³ Although sixteenth century authors illustrate some of these alternatives, it is not until the early seventeenth century, with Marolois, Accolti, and Aleaume that these illustrations are accompanied with precise quantitative measurements. By the latter seventeenth century physical models are commonly being used to demonstrate these principles and in the eighteenth century such models take their place in *cabinets de physique*. Such links with instruments and models assure that the principles of perspective remain associated with practical demonstration.

Objects

Practical demonstrations also affect perspectival examples in the treatises. Ever since antiquity the regular solids were associated with metaphysics (cf. Plato, *Timaeus*), and treated in terms of abstract geometry (Euclid). By 1489 Pacioli makes models of these. Between 1496 and 1499 Leonardo renders these three-dimensionally in perspective and they are soon published in Pacioli's *Divine proportion* (1509). Thereafter regular solids become a standard theme in treatises on perspective, although the attention given them varies greatly. Dürer (1525) and Danti (1583) deal with them in passing; Sirigatti (1596) devotes a major section, while Lencker, Jamnitzer and Halt make it their chief theme.

Authors are increasingly conscious of a cumulative dimension in their efforts. If Pacioli (1509) borrows from Piero implicitly, Barbaro (1569) is explicit concerning his debts to Piero, Pacioli and Dürer. Pfintzing (1598) goes further by reconstructing what each generation of Nürnberg artists added to the tradition. This awareness applies not only to the regular Platonic and semi-regular, Archimedean solids, but also to a series of nearly regular forms. Leonardo, for instance, draws a six-sided cross. This form recurs in Dürer, Lencker, Halt, continues as a motif until the nineteenth century when it becomes connected with discussions of the fourth dimension, and appears in the twentieth century in Salvador Dali's *Crucifixion*. The same happens with forms such as lutes, chairs, columns, and stairs. Just as a series of local stock images emerges in the practical tradition, so too do a series of standard images within the printed perspectival treatises.

Buildings

The treatises on perspective also introduce a series of standard images of buildings. Here a more complex process of dissemination is at play. In the fifteenth century artist/architects including Brunelleschi, Alberti and Francesco di Giorgio Martini make increasingly systematic studies of Roman ruins. These forms are copied, but also adapted for different purposes in other media. Francesco di Giorgio Martini, for instance, records an ancient circular temple in his *Trattati d'architettura*. Leonardo uses a similar form in his plan for a modern mausoleum, as do the master of the Urbino panel in his idealized view of a city, and Bramante in his actual construction of the *Tempietto* in Rome.

A symbiosis develops between ancient and modern, idealized and actual forms. Printing augments this process. When Serlio inherits Baldassare Peruzzi's work and publishes it, he includes ruins and modern buildings together in his works on architecture. Androuet Du Cerceau develops this approach including, for example, an engraving of Bramante's modern *Tempietto* amongst examples of Roman ruins. He also produces a first edition of the principal monuments of France. Here real and idealized elements are so intertwined that debates still continue as to what extent they represent actual buildings or idealized conceptions.

Androuet De Cerceau's work marks a new departure in another sense also. Many of his publications are simply collections of perspectival examples without theory. Jan Vredeman de Vries, develops this new type of picture book, combining a free interpretation of Vitruvius and images of Roman ruins, in arriving at his idealized versions of modern buildings. Some of these look so outlandish that they seem examples of an imagination run wild. Yet a number of their elements recur in actual mannerist and baroque architecture. For instance, decorations on the roof of the *Armoury* in Wolfenbüttel are clearly related to those in the treatises of Vredeman de Vries. Hence an interplay between ancient and modern, real and imaginary images in printed perspectival texts not only expands the horizons of phantasy on paper, but also affects paintings, architectural plans and architecture itself.⁴⁴

Environments

Indeed this process gradually includes the whole environment. Barozzi il Vignola's design of Caprarola and Michelangelo's reorganization of the Capitoline offer two early examples where the side buildings are deliberately arranged in order to make the principal building look closer than it actually is to the approaching viewer. This use of perspective in order to control the viewer's perception of space is soon applied to landscape gardening, the principles of which Du Pérac brings from Italy to France in 1583, where it is developed by the Mollets and Le Nostre culminating in Vaux Le Vicomte and ultimately Versailles.⁴⁵

Seventeenth century treatises on perspective do not reveal all the secrets of these extraordinary new gardens. Dubreuil and Bosse outline the problem in general terms. Gardening texts discuss the principles without illustrations. By the latter part of the century there are numerous engravings and by the early eighteenth century Paulus Decker provides extensive instructions about how to transform a normal landscape into an entirely perspectival one. By this time perspective offers a means of rendering the whole of reality playfully, whence it becomes so central to baroque and rococo art and culture.

Plays between Reality and Fiction

This is not to say that perspective has a simple trivializing function. The introduction of a fictive painted perspectival triumphal arch in the midst of a real garden at Reuil, or the illusionistic landscape view at Schwetzingen are optical games to entertain those whose

lives of leisure are spent strolling in gardens and palaces. They are also expressions of an absolutistic society through which a single individual imposes a coherent pattern on nature; where artifice is a positive term, where all the world is literally a stage and viewpoints change continually. As Professor Sinisgalli⁴⁶ has shown so dramatically, the passageway in the Palazzo Spada is not a simple perspectival tunnel. It has 15 different vanishing points such the effects change as the viewer approaches and walks through the structure. Whereas the early perspectival vaults and tunnels in the works of Masaccio, Fra Angelico and Domenico Veneziano are static, those of Borromini or the gardens of Versailles are dynamic. A combination of perspective and printing brings a revolution in both the treatment of space and the imagination. But it evolves slowly, showing its first serious effects approximately a century after Gutenberg, its full consequences not being evident until another two centuries pass.

5 New Interpretation

The above leads us to reconsider earlier claims. McLuhan assumed that perspective was necessarily connected with literacy. This is 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 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 first 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 has effectively no impact on perspectival treatises.

McLuhan's assumption that printing and perspective are necessarily linked is, therefore, untenable. McLuhan's suggestion of connections between the development of a particular point of view in literature and a specific viewpoint in art is also misleading because it tends 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 literature⁴⁷ and although 2) and 4) presumably fall under the aegis of *reception theory*,⁴⁸ 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, who is said to have been a starting point for McLuhan was, therefore, also misleading in claiming that in perspective: "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."⁴⁹

As we have shown 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.

Had Professor Eisenstein understood this 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".⁵⁰ 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 the Dominican order. 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 above. This could readily be expanded to include links between perspective and instruments: the first perspective treatise also contained the first description of a perspectival instrument (1434).

Leonardo's notebooks which first describe the inverse size distance law also contain a first illustration of a perspectival instrument (c. 1490). The period 1500-1527 brings the first printed treatises in France and Germany and a first printed illustration of a perspectival window. The period 1527-1600 sees the spread of printed treatises to the Netherlands, England, Spain, Austria and Poland. With respect to instruments it sees early attempts at a universal measuring device. The period 1600-1800 brings 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 are encyclopaedic (e.g., Leupold, Kästner) or simply popularizing (e.g., Dubreuil). This period also sees the development of the Galilean sector and Bürgi type proportional compass which are successful universal measuring devices. The new confidence and universality this brings to the realms of science, is reflected in the confidence with which perspective is gradually applied to the entire environment and reflected in turn in the new confidence of politicians making absolutist claims for power.

Learned scholars such as Crombie⁵¹ may have demonstrated that the fundamental Greek heritage of a quest for truth and indeed that key terms such as experiment and observation remain constant from the thirteenth through the seventeenth centuries; that persons kept quoting Aristotle and Plato, kept depending on Euclidean geometry and made similar philosophical claims rhetorically. Seen in this context, there is a continuity via texts and print culture linking Fibonacci and Grosseteste with Galileo's approach. But there are also basic factors that change such as perspective and instruments. These create 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 is slow, cumulative and incontrovertible, leading from

Fibonacci (13th c.) through Regiomontanus (15th c.) to Leonardo da Vinci (16th c.) and Galileo (17th c.), such that Galileo's world also seems fundamentally different from that of the middle ages.

A considerably more complex picture than that offered by Ivins, McLuhan, Panofsky, Eisenstein or Gombrich thus emerges. 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; various 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 ones 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 a revolutionary way which affected not only a spatial representation 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 are razed to raise a view, and Versailles where an horizon is altered to suit a sun king.

Eisenstein's book argued for a sudden revolution in printing, making the 1480's a turning point, in order to settle fluid boundaries between mediaeval and renaissance culture. Our analysis has shown that the fundamental implications of printing emerges only gradually in the course of three centuries; that printing in isolation is ill suited to settle boundary disputes in the wars of periodization and that perspective offers a better framework for understanding one of the most dramatic transition periods in history.

6. Time and Motion

If printing plays an important role in the spread of perspective from the sixteenth century onwards, it also imposes basic limitations on the perspectival process. Especially in its early period printing is limited mainly to words. Diagrams remain problematic. In the case of a perspectival view, an observer sees an object from a given viewpoint at a given time. The printing of such a view poses serious problems at least until the 1540's and it is not until the eighteenth century that luxury engravings come into their own. There are deeper problems. Diagrams are static: perspectival constructions are dynamic, and involve a series of steps. In a frontal view an artist 1) establishes the height of the observer, 2) draws an horizon line and 3) ground line, 4) fixes a principal vanishing point and 5) draws orthogonals that converge to this point. This frontal view is usually coordinated with a side view by means of which an artist 6) establishes the distance point, 7) draws diagonals to this distance point in order to arrive 8) at the perspectively foreshortened squares of a pavement. Each of these eight steps involves time and motion. In a printed book all the steps are typically summarized in a single static diagram, which gives no hint of the particular sequence of steps required to achieve this result.

To complicate matters diagrams in the Euclidean mathematical tradition were conventionally two dimensional.⁵² Hence the two views of a perspectival construction are usually swung round to a single plane and what had originally been a concrete three

dimensional situation is conveyed as an abstract diagram that is incomprehensible to all but a few experts. Hence, while printing is responsible for the dissemination of renaissance perspective, it frequently spreads a static, two dimensional version of these new rules for spatial construction, which ignore entirely factors of time and motion. The emergence of parallel perspective in the seventeenth century and various branches of axonometric perspective (isometric, dimetric, and trimetric) in the nineteenth century provide a spatial framework within which changes in linear perspective can be recorded. But even these solutions typically present only the final stage, thus obscuring the series of steps used in reaching these end results.

For this reason the assumption shared by almost all art historians that perspective was strictly a renaissance phenomenon belonging to the fifteenth and sixteenth centuries, or at best something that lingered on until the time of Cezanne, is wrong. Indeed although perspective is inevitably associated with renaissance painting and printing, neither of these media was capable of conveying the temporal and kinetic dimensions that it implied. Ironically the electronic media, which McLuhan associated with a rejection of the visual and a return to auditory/tactile space, offer a new range of visual dimensions including a means of illustrating these complexities of perspective for the first time. A motion picture or video camera can record sequences of perspectival images as an object is moved away from or towards an observer and picture plane, showing how these images change in size and demonstrating the inverse size distance law. A computer screen with graphics capabilities can illustrate a series of steps such as those outlined above in connection with the distance point, making clear their precise sequence such that one sees clearly how a demonstration progresses from its first step to its final stage. The dynamic feature of graphics programmes thus brings into focus temporal and kinetic aspects of perspective of which printing was incapable.

The emergence of these new media and renewed interest in the history of perspective have gone hand in hand. Is it a co-incidence that the rise of motion pictures in the 1920's occurred in the same decade that Panofsky wrote his landmark essay on perspective as a symbolic form; or that the enormous increase in electronic media in recent years has been paralleled with an immense rise in literature on perspective? In 1939, when Novotny wrote his *Cezanne and the end of scientific perspective*, it seemed as if perspective had been a renaissance phenomenon that was no longer relevant. Since then as new media have revealed new consequences of perspective we are being challenged to look afresh at its origins in the renaissance. Paradoxically we often study as past phenomena precisely those themes that surround us in the present and are so common that we take them for granted. Studying these themes historically is one of the ways of distancing ourselves from present, dominating concerns.

7. Dynamic Knowledge

These developments in perspective are basic: they imply a new approach to knowledge itself. Printing with its linear mode emphasized static knowledge, universally applicable cases, which are timeless, epitomized by statements, claims, propositions, formulae and laws. The new electronic media are implicitly multilinear, polyvalent, involving dynamic

knowledge, particular situations, changing with time and epitomized by experimentation, model making, demonstrations, systems, processes.

Cassirer⁵³ argued that the Renaissance introduced a shift from substance to function, from *what* questions to *how* questions. We would note that printing kept the shift largely at a verbal level, although scattered diagrams illustrated isolated aspects. The new electronic media are making this shift visual such that one can see not only what but also how an object, machine, system or process operates and functions by means of a series or sequence of images, using animation in its broadest sense. Printing permits static perspective which provides spatial representation of single elements. Electronic media enable dynamic perspective which gives a spatio-temporal context.⁵⁴ Instead of showing a situation in isolation this allows us to see where it occurs in a spectrum: how different scales relate to one another; how original and model, construction and reconstruction, how concrete and abstract relate. Whereas printing focussed on isolated parts, electronic media provide views of processes as a whole, enabling us to see which are cyclical, which are reversible or irreversible.

Traditionally verbal logic has been one of the guiding principles in the organization of knowledge. Hence ideas have been structured as identities or oppositions, dyadically as either/or. Accordingly comparison and contrast have frequently also been in these terms: yes/no, black/white, even in moral terms: good/bad. Visual ordering includes identities and oppositions, but also involves scales of size or abstraction, shadings, parameters and tolerances. This introduces a quantitative dimension to comparison and contrast. An object that is off-white is not necessarily black: it is somewhere on a colour spectrum and can be measured. How near or far objects are from being identical can be measured. Relationships between objects become visible and quantitative. Only visible objects and phenomena and effects that can be translated into visible graphs or charts can be measured. For this reason visualization and quantification are so integrally connected and both are fundamental to the rise of early modern science.

It may seem that we have lost our thread: that these developments, while fascinating, have nothing to do with perspective. Patience is necessary to see the connection. Ancient conceptions of knowledge in terms of substance focussed on what an object is, on its tactile qualities, which were qualitative, not measurable and usually static. The shift from substance to function in the renaissance brought a new attention to visible aspects of change and motion, which assumed lack of contact with the object and distance, were dynamic and quantitative. Perspective is effectively a method for recording changes of size and shape, effects of distance, and motion: a framework for seeing objects dynamically, quantitatively in terms of functions, operations, systems, processes.

James Burke devoted a session of his series *The Day the World Changed* to the discovery of perspective. He emphasized the importance of the grid system in perspective and argued that this was responsible for modern cartography, for the development of urban planning as we now know it and even contemporary military devices involving radar and other tracking capabilities. In fact, the implications go far beyond this. For the creation of a universally applicable spatial grid allows us to transport coordinates coherently in time

and space in the creation of virtual realities, whereby an individual in one place can be *co-ordinated* with an individual in another place and time and thus enter into a new type of communication. Conference telephones permit a person in Toronto to speak simultaneously with someone who has just woken up on the west coast and someone about to go to bed in Europe. The principles of perspective applied to virtual reality make it possible for the same person to see these individuals in both future and past time. Virtual reality brings a whole new meaning to the traditional concept of machines as extensions of man. For this principle potentially enables a physicist or engineer to be connected with a robot which can then enter physically a space that the human only enters virtually. In future a Chernobyl situation could be avoided by robots doing repair jobs where humans could not enter without mortal risk. Adding scale factors and miniaturization, a medical doctor could perform operations inside the human body.

Two decades ago such a *Fantastic Voyage* was the subject of a science fiction film. Within a decade this could become a reality. Much more is possible. Given Jung's discoveries about the universal aspects of dreams, the collection of photographs of archetypes at the Warburg Institute could be scanned and translated into three dimensional simulations. Persons could then literally recreate their dreams and enable persons visual glimpses into simulations of their mental horizons. A sceptic will rightly note that dreams present spatial dimensions independent of time and that any attempt at sequential reconstruction introduces a distorting temporal dimension into the process. But this is true of all attempts to reach out from one individual to the other, be it with words or pictures. It is true of all communication. Even so these new tools paradoxically promise to bring us closer to sharing inner worlds while at the same time externalizing and distancing ourselves from the core of our being. Perspective of ourselves is a way of gaining a perspective on ourselves. In any case it is a new journey into the interplay of spatial-temporal dimensions at a conscious level. Neither the Renaissance nor even the nineteenth century had any inkling of these dimensions. In a sense we are only now beginning to fathom the profound implications of perspective in this deeper sense: as a dynamic, externalizing tool for exploring new horizons of the natural, man made and the personal worlds.

8. Conclusions

Perspective and print culture have undeniable links. Printing has made over 8000 perspective texts and manuals available to readers in most countries of the world, The connections are, however, limited. Spatial motifs of perspectival scenes emerged in painting practice in Padua and Assisi a full century and a half before the advent of printing. It was over forty years after Gutenberg that the first perspective treatise was published. Even then printing remained text oriented and forced perspective with its visual dimensions into static straight-jackets that obscured its temporal and kinetic functions. By the nineteenth century this led some important artists to reject perspective. In retrospect we can see that they were in fact rejecting the limitations imposed on perspective by Renaissance printing, which constrained perspective to making isolated stills, snapshots, rather than kinematic records. The new electronic media are revealing the enormous implications and full potentials of perspective for the first time. The old

textbooks on the subject may go out of print, but perspective is about to imprint itself on western culture with a new intensity as it transforms how we see the structures of knowing, challenging us to reorganize what and how we know, changing the very meaning of knowledge.

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Notes

¹ William M. Ivins, Jr., *Prints and Visual Communication*, Cambridge Mass., M.I.T., 1969, p. 24.

² Marshall McLuhan, *The Gutenberg Galaxy*, Toronto: University of Toronto Press, 1969, p. 56.

³ *Ibid.*, p. 138.

⁴ *Ibid.*

⁵ Cf. Philip Marchand, *Marshall McLuhan. The Medium and the Messenger*, Toronto: Vintage, 1990, p.98.

⁶ *Ibid.*, p.124, who cites: McLuhan speech in *Empire Club Addresses*. Letter to Harold Rosenberg, March 1 1965. "Probe for *Foundations*", unpublished note, National Archives of Canada.

⁷ *Ibid.*, p. 124 who cites: Letter to James Carey, 25 March 1974; Letter to Tim Bost, 28 Jan 1974. *Playboy* interview. Diary, 4 August 1978.

⁸ *Ibid.*, p. 122-124.

⁹ *Ibid.*

¹⁰ *Ibid.*, pp. 54-57, 59, 63-64, 67, 70, 82, 90-92, 110, 114, 152, 155, 243.

¹¹ *Ibid.*, p.124.

¹² *Ibid.*, p.246.

¹³ *Ibid.*, p.246, who cites: Letter to Christine Breech, 9 November 1976. Letter to Richard Berg, 14 September 1976.

¹⁴ *Ibid.*, p.246, who cites: Letter to David Nostbakkee, 10 August 1976. Letter to David Staines, 4 August 1976. Interview *Maclean's*.

¹⁵ Elizabeth L. Eisenstein, *The Printing Press as an Agent of Change*, Cambridge: Cambridge University Press, 1979, p. 186.

¹⁶ *Ibid.*

¹⁷ *Ibid.*, p. 269.

¹⁸ *Ibid.*, p. 252, 548.

¹⁹ *Ibid.*

²⁰ *Ibid.*, p. 548.

²¹ *Ibid.*, p. 589.

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- ²² Ibid, pp. 173, 183, 190, 193, 200, 238, 257, 262, 292, 469, 588.
- ²³ Sir E. H. Gombrich, *Art and Illusion*, Princeton: Princeton University Press, 1960, p. 129. (A. W. Mellon lectures in the Fine Arts 1956. Bollingen Series XXXV.5).
- ²⁴ Sir E. H. Gombrich, *Means and Ends. Reflections on the History of Fresco Painting*, London: Thames and Hudson, 1976, p. 32. (Eighth...Walter Neurath Memorial Lecture).
- ²⁵ Ibid., p. 35.
- ²⁶ Alessandro Parronchi, *Studi sulla dolce prospettiva*, Milan: Aldo Martello, 1964, p. 119.
- ²⁷ Cf. *L'Opera completa di Masaccio*, ed. Paolo Volponi, Milan: Rizzoli, 1968, pp. 96-97. (*Classici dell'arte*, vol. 24).
- ²⁸ Sven Sandström, *Levels of Unreality*, Uppsala: Almqvist & Wiksells, 1963. (Figura. Uppsala Studies in the History of Art. New Series, 4).
- ²⁹ For further connections see the author's "Perspective, Anamorphosis and Vision": *Marburger Jahrbuch für Kunstwissenschaft*, Marburg, Bd. 21, 1986, pp. 93-117.
- ³⁰ Antonio Manetti, *The Life of Brunelleschi*, ed. Howard Saalman, University Park: Pennsylvania State University, 1970, p. 42.
- ³¹ Michael Kubovy, *The Psychology of Perspective and Renaissance Art*, Cambridge: Cambridge University Press, 1986, p. 52ff.
- ³² Ibid., p. 140ff.
- ³³ The narrative aspects of this cycle have been explored by Eiko Wakayama, "La prospettiva come strumento di visualizzazione dell'istoria: il caso di Masolino": *La prospettiva rinascimentale*, ed. Marisa Dalai Emiliani, Florence: Centro Di, 1980, pp. 151-163.
- ³⁴ Brian Stock, *The Implications of Literacy*, Princeton: Princeton University Press, 1983, p. 91.
- ³⁵ The problem of literacy relates to basic problems in the classification of art, a topic explored briefly in the author's "A New Classification for Art", *Studien zur Klassifikation*, (Frankfurt: Indeks Verlag, Bd. 17, 1986, pp. 76-84.
- ³⁶ See, for instance, Erwin Panofsky, "Die Perspektive als symbolische Form": *Aufsätze zu Grundfragen der Kunstwissenschaft*, ed. H. Oberer, E. Verheyen, Berlin: Bruno Hessling, 1974, Abb. 22.
- ³⁷ See Rob Ruurs, *Saenredam*, Amsterdam: Benjamins/Forster, 1987. (Oculi. Studies in the Art of the Low Countries, 1)
- ³⁸ Lewis B. Andrews, *A Space of Time: Continuous Narrative and Linear Perspective in Quattrocento Tuscan Art*, PhD, Columbia University, 1988.
- ³⁹ Rob Ruurs as in note 37.
- ⁴⁰ Elizabeth Eisenstein, as in note 5, pp. 167, 171, 299-300.
- ⁴¹ These statistics and the ones in the pages following are provisional results of a bibliography on which I have been working for the past decade. Any attempt at quantification is beset by more problems than a simple chart suggests. I have included in my definition of a treatise of perspective all those books included in previous bibliographies; e.g., Poudra, Riccardi, Loria, Vagnetti, plus those which contain some reference to perspective in the title.

⁴² See the author's *Linear Perspective and the Visual Dimensions of Science and Art*, Munich: Deutscher Kunstverlag, 1986.

⁴³ *Ibid.*, pp. 389-402 gives an historical analysis of these two terms.

⁴⁴ For a further discussion see the author's *Sources of Perspective*. .

⁴⁵ See F. Hamilton Hazelhurst, *Gardens of Illusion. The Genius of Andre Le Nostre*, Nashville: Vanderbilt University Press, 1980.

⁴⁶ Rocco Sinisgalli, *Borromini a quattro dimensioni*, Rome: Università degli studi, 1981.

⁴⁷ See, for instance, Jaap Lintvelt, *Essai de typologie narrative. Le 'point de vu'*, Paris: Librairie José Corti, 1981. With respect to mediaeval literature see, for example: Hugo Kuhn, "Minnesang als Aufführungsform" *Hartmann von Aue*, Darmstadt: Wissenschaftliche Buchgesellschaft, 1973, pp. 478-490. Professor Green [Cambridge] has explored point of view in *Parsifal* and other mediaeval texts

⁴⁸ 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 10 above.

⁴⁹ S. Giedion, *Space, Time and Architecture*, Cambridge, Mass.: Harvard University Press, (1941), 1977, p. 31.

⁵⁰ E. Eisenstein, as in note 5, p. 269.

⁵¹ Alistair Crombie, *Robert Grossteste and the Origins of Experimental Science*, Oxford: Clarendon Press, 1953.

⁵² Cf. Jane Andrews Aiken, *Renaissance Perspective: its Mathematical Source and Sanction*, PhD, Harvard University, 1986.

⁵³ Ernst Cassirer, *Substance and Function*, Chicago: Open Court Publishing Co., 1923. Reprint: New York: Dover, 1953.

⁵⁴ For an introductory consideration of some possibilities see: Scott Edward Kim, *Viewpoint: Toward a Computer for Visual Thinkers*, PhD, Stanford university, 1988.