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# Paradoxes of Perspective: Ideal and Real Cities

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## 1. Introduction

There is a received wisdom concerning the development of linear perspective. In Antiquity, we are told there was some or perhaps even a complete mastery of the rules of (linear) perspective. During the Christian Middle Ages a focus on other-worldly spiritual values undermined this realistic treatment of worldly, physical space. From the thirteenth century onwards, there was a revival in naturalism, which culminated in the Renaissance (rediscovery) of linear perspective at the time of Brunelleschi (c.1415-1425).[1] In theory this should have brought about a revolution in the realistic representation of towns.

In practice this was not immediately the case. A seeming realism in the depiction of the built environment is evident already at the time of Giotto at the beginning of the fourteenth century. On closer inspection, however, this seeming realism serves another purpose. It is subordinated to the interests of narrative[2] and leads to ideal rather than real cities. This tradition continues in the sixteenth century in the context of theatre. As a result many constructions are rhetorically convincing but are physically unlikely or even impossible.

From this insight emerges a much more complex early history of perspective, whereby we can discern two fundamentally different purposes: one is concerned with depiction of idealized spaces for storytelling and narrative; another is concerned with quantitative measurement and realistic measurement of the physical world. The roots of these different purposes can be found in Antiquity. The evolution of linear perspective is at first more closely linked to idealized narrative than to physical realism. Only gradually do these two purposes coalesce to become one. But this process takes more than a century and a half. It is not until the mid sixteenth century that this process becomes clear and not until the early seventeenth century that it

becomes fully codified. Dramatically stated: there was no "revolution" in linear perspective. There was a commitment to realism which began as early as the 12th century and which took four centuries to evolve into the laws of perspective as we now know them.

## 2. Roots in Antiquity

The Latin term for perspective, *perspectiva*, is a translation from the Greek term for optics, *όπτική*. Scholars such as Theisen[3] have drawn attention to a puzzling feature in Euclid's *Optics*. The text is mainly about psychological aspects of vision: how objects look smaller at a distance, how square objects appear rounded at a distance etc. These themes take up 53 of the 57 propositions. By contrast, four propositions (19-22) are concerned with surveying problems, namely, what things are rather than how they seem in terms of heights of buildings etc. Within Euclid's *Optics* this (potentially) quantitative strand appears almost an anomaly in an otherwise qualitative text.

By the 9th century, within the Arabic tradition, this anomalous aspect of Euclid's Optics acquired new significance. Al Farabi in his discussion of the sciences defined optics as a science involved with measurement of distances and heights.[4] Hence, a part of optics effectively became equivalent with surveying. This explains why considerable parts of Alhazen's (Ibn al Haitam's) *Book on Optics* (*Kitab al Manathir*) are devoted to the certification of sight at a distance.[5] Alhazen's work was the basis of a major compendium on Optics written by Witelo at Viterbo soon after 1269.[6]

Witelo's treatise became a starting point for John Peckham, the Archbishop of Canterbury's *Perspectiva communis*, which became the most important textbook of optics in the latter Middle Ages. Manuscript annotations by Cesare Cesariano in a Milanese edition of Peckham contain one of the earliest perspective sketches.[7] This tradition explains also why treatises on optics and surveying often occur together from the thirteenth through the sixteenth centuries. Indeed one of the early perspectival demonstrations in Francesco di Giorgio Martini's treatise on surveying[8] derives directly from Euclid's *Optics* (proposition 10). Thus there were obvious connections between optics, surveying, and perspective. However, the story is more complex.

## 3. The Narrative Tradition

Giotto was chief of fortifications in Padua and must therefore have been acquainted with surveying of physical objects and territories. We might expect, therefore, that his frescoes at Assisi, Padua and Florence would represent places which are recognizable in the physical world. They do not. One of the scenes in the Life of Saint Francis, the Hommage of a Simple Man, shows him placing a cloth on the ground such that Saint Francis can walk over it.[9] In the backgound are buildings, which look realistic. When we look more closely we note that what appears to be a church has no doors. In other words, the depicted architecture functions merely as a backdrop for the narrative. The architecture would have no functional use as physical buildings.

This problem is even more apparent in Giotto's *Ascension of the Evangelist* in the *Life of Saint John the Evangelist* (Peruzzi Chapel, Santa Croce, Florence, 1320).[10] Here again the buildings look realistic. On closer scrutiny, we see how Saint John is being lifted up into heaven through an opening in the building. The depicted building clearly

separates the story into distinct groups and episodes. On the other hand, this could hardly be a physical building: a central open section would mean that rain and other effects of weather could enter directly into the building. In short, Giotto has depicted a structure, which is excellent as a backdrop for his narrative but which has no use in the physical world.

A similar approach is also evident in Northern art. At first sight, Roger Campin's Wedding of the Virgin (Prado) depicts realistic structures. On closer examination we see only the façade of a Gothic church in the foreground and a round temple, a symbol of the Temple of Solomon in the background.[11] As Professor Colorado has noted elsewhere in this volume, the symbolic focus is on a contrast between the New Testament in the foreground and the Old Testament in the background. In other words the narrative determines the elements of the painting. What looks realistic is symbolic.

**4. Physical Realism**

The steps towards physical realism proceeded slowly. In the first quarter of the thirteenth century, Simone Martini was hired specifically to map the Sienese territory. A fresco (1328) attributed to Simone Martini shows us only a very idealized view of Sassoforte and Massa Marittima. A decade later Pietro Lorenzetti painted his fresco of *Good Government* (1337-1340) again with highly stylized views of Siena and the surrounding countryside. Strikingly, his most impressive proto-perspectival work was in a religious painting of the *Annunciation* (Siena, 1344). In short Lorenzetti's most realistic depiction of space was in a spiritual/mental world of narrative rather than in a depiction of the physical world.

Brunelleschi's depiction (c.1415-1425) of the Baptistery in Florence is said to have been the first perspectival demonstration. In theory this should have marked a great step forward in the depiction of octagonal or hexagonal buildings. In practice, we note that Gentile da Fabriano's predella with the *Presentation in the Temple* (Louvre, 1423), thought to have preceded Brunelleschi, is very convincing. Examples of such figures in the perspective treatise of Filarete,[12] three decades later are surprisingly primitive. In other words the advent of perspective brought no sudden mastery of physical space.

Indeed the earliest major examples of perspective after Masaccio's *Trinity* are all narratives involving religious scenes including Masaccio's/Masolino's *Life of Saint Peter* (Brancacci Chapel, Florence, c. 1427); Masaccio's/Masolino's *Life of Saint Catherine* (San Clemente, Rome, 1429) and Masolino's *Life of John the Baptist* (Castigione d'Olona, c.1435). Here again depictions of architecture serve the narrative rather than to record physical places.[13]

Meanwhile, some of the first examples of clear depictions of buildings in the physical world occur outside the perspectival tradition: e.g. in the *Très Riches Heures* of the Limbourg Brothers (1413-1416). Here we see, for instance, the Sainte Chapelle in Paris. These occur in the North and are clearly a point of departure for Jean Fouquet's depictions of the Saint Chapelle [14]and Notre Dame[15] in the *Livre d'Heures d'Etienne Chevalier.* In this manuscript we find also the first clearly identifiable church interior showing the North aisle of Notre Dame.[16] A number of other church interiors in *Annuciations* by artists such as Jan van Eyck (e.g. Washington, 1434-1436; Berlin,

1436-1437), and Robert Campin (e.g. Prado, 1438) look very convincing but cannot be linked unequivocally with a given building.

Numerous examples of clear depictions of physical places occur from the second quarter of the 15th century onward in Northern painting independent of linear perspective: e.g. Konrad Witz's representation of the Môle and Mont Blanc in his *Miraculous Draught of the Fishes* (Zurich, 1444); H. Bornemann's *View of Lüneberg* (Nikolaikirche, Lüneburg, 1444-1447).[17]

In the second half of the fifteenth century, there is a gradual rapprochement between linear perspective and physical reality. In Piero della Francesca's *Baptism* (National Gallery, London, 1450s), we see the birthplace of Piero, the town of San Sepolcro in the background. In 1457 we find a view of Rome from Monte Mario in a Vatican manuscript of Euclid's *Optics*.[18] In 1458 we find a view of San Sepolcro in another Vatican manuscript of Euclid's *Optics*.[19]

In Ghirlandaio's cycle of *Saint Fina* (San Gimignano, 1473-1476) we can clearly see the towers of the city in the background although their significance is subordinated to the story of the saint and her followers who dominate the narrative. Jacopo del Sellaio's *St John the Baptist* (National Gallery, Washington, c.1480) which shows Florence in the background is another example. Ghirlandaio's *Life of Saint Francis* (Sassetti Chapel, Florence, 1480), shows us both the Piazza della Signoria and a street view in front of Santa Trinità leading to one of the bridges of the Arno, a scene which recurs in modified form in Lionardo Salviati's play, *Il Granchio* (1566).

One might expect that as Ghirlandaio progresses there would be an increasing "realism" in the sense of ever more depicted places with clearly recognizable correspondence with the physical world. This is not the case. If we examine his frescoes in Santa Maria Novella (1485-1490), we find some features, which clearly relate to the Florentine townscape. Many others are clearly idealized backdrops rather than realistic copies of a physical place. Pinturicchio's cycle, in Santa Maria in Aracoeli is even more like a stage setting. Perspective, which might have led to a mastery of physical space, often led to a mastery of imaginary space.

## 5. Theatre

One of the reasons why perspective was so clearly linked with idealized cities in narrative was through close connections with theatre and specifically stage scenery. Brunelleschi was active with respect to both perspective and stage scenery. These connections between theatre and perspective are evident throughout Italy. An early woodcut from Ferrara shows perspective applied to the Piazza del Pace. Perspective is thus used to transform an existing physical space into a depiction of a ludic space. Similarly, a drawing from the circle of Girolamo da Carpi shows the Piazza of Ferrara (c.1550) in an idealized form. An early engraving by Serlio has the same transformative effect on Saint Mark's Square in Venice (c.1532). A drawing by Domenico Beccafumi transforms the city of Pisa (c.1539) into a theatrical perspective. A draught (*bozzetto*) by Federico Zuccari for the Cofanaria (1565) transforms a distant view of Florence into a theatre scene. Two drawings by Baldassare Lanci transform the inner town of Florence into a theatrical perspective

(1567, 1569), as does a schematic drawing of Orzio Scarabelli for theatrical apparatus (1569).

This trend is also evident in Rome where we find drawings by Baldessare Peruzzi which juxtapose a series of landmarks from the eternal city such as the Pantheon, Castel Sant'Angelo, Colisseum and the Column of Trajan into stage settings, variations of which then become the tragic and comic stage settings in Sebastiano Serlio's treatise on perspective. These entailed idealized combinations of real cities for the construction of stage scenery. By 1544, this treatise was published as his Second book on Architecture (Venice).

It is quite likely that the early publications of Jacques Androuet du Cerceau, first in Orléans (1545) and subsequently in Paris (1557?, 1559, 1560) were also intended for theatre decorations and/or as models for intarsia. In any case it is significant that these editions show idealized buildings, landscapes and cities of ruins rather than being careful copies of physically existing ruins. The title of a 1549 edition specifically states that the scenes are "partly invented by me, partly taken from monuments in Rome and elsewhere."[20] Such idealized views are also provided in books by Gerard de Jode (1550, 1560), Hieronymus Cock (1551, 1562), Vredeman de Vries (1560 ff.), Giovanni Battista Pittoni (1561, 1571), Hans Blum (e.g. 1566) and Lorenz Stoer.[21] In the next decade the editions of Antonio Labacco (1570), Andrea Palladio (1570), Etienne Du Perac (1575) and Antoine Lafréry (1570), publish works where the realistic aspect of antiquity begins to come into focus. By 1572 Braun and Hohenberg also publish their Cities of the World.[22] Thus the publication of realistic versions of ruins and contemporary cities goes hand in hand.

From Vasari we know that many of the early pioneers in perspective were actively engaged in the use of measuring and surveying, including Brunelleschi, Donatello, Alberti, Domenico Ghirlandaio, Antonio da San Gallo, Simone Polailluolo, Giulio Romano, Girolamo Genga, Baldessare Peruzzi, Bramante, Bramantino and Jacopo Barozzi il Vignola.[23] We know that Serlio made similar studies. In retrospect we can note that most of these drawings dealt with perspectival treatment of individual elements such as columns, capitals, bases, rather than of perspectival views of landscapes. Some of these individual studies made their way into the works on columns and orders of architecture of authors such as Serlio and Blum. But the great majority of these drawings were not published at the time.

Thus perspective which could have led to a copying of the physical world, led rather to a transformation of the physical world into playful, imaginative and idealized stage settings which led directly to the capriccios of the seventeenth century.

## 6. Perspective and Surveying

It is in the North that we find closer connections between perspective and surveying. These connections are evident in constructed architecture prior to their appearance in depicted architecture. Already in the late 12th century at the Cathedral of Laon (1160-1205), we find a spatial entrance, which produces a perspectival effect.[24] In the early thirteenth century, in the famous Sketchbook of Villard de Honnecourt (c.1230) we find a nail and string method for the construction of *voussoirs*, which bears an uncanny resemblance to the vanishing point.[25]

In the fifteenth century, we find convincing maps of Florence (c.1475, 1490) without direct evidence of perspective.[26] In the North, prior to the introduction of perspective, we find a realistic city view of Nürnberg in the Krellscher Altar (St. Lorenz, Nürnberg, 1483). We find a realistic view of Cologne in a painting by the Meister of the Verherrliching Mariae (Wallraff Richartz Museum, late 15th century). It is Albrecht Dürer who provides realistic views of Innsbruck from outside the city and inside the city (both 1494) before he has learned perspective in Italy.

Dürer's treatise on perspective is called *Instruction in Measurement* (*Underweysung der Messung*, Nürnberg, 1525). Just over a decade later a treatise attributed to Hieronymus Rodler A Fine, *Useful Booklet and Instruction in the Art of Measurement* (*Ein schön nützlich Büchlein und Underweisung der Kunst des Messens*, 1536), makes explicit the connection between perspective and surveying. In the 1560s there are new links between perspective and the use of instruments through the work of Wenzel Jamnitzer (1564, 1568), Heinrich Lautensack (1564) and Hans Lencker (1567).

In the second half of the sixteenth century, these connections between perspective and surveying also become evident in Italy. Giacomo Lantieri publishes *Two dialogues*… on the manner of drawing ground plans of fortresses according to Euclid and on the manner of composing models and put into drawing the plans of cities (1557).[27] Silvio Belli publishes a *Book on Measuring with Sight* (1564, 1565, 1570). Egnazio Danti, the official cosmographer of the Duke of Tuscany, is active in Sala del Mappamondo in the Palazzo Vecchio. Later he is active in the hall of the maps in the Vatican. The same Egnazio Danti becomes the editor of Jacopo Barozzi il Vignola's *Two Rules of Practical Perspective* (Rome, 1583).

**7. Synthesis**

As early as 1558, Federico Commandino published his commentary on Ptolemy's Planisphere. This heralded a trend whereby astronomy and perspective became linked simultaneously with a high level theoretical mathematical tradition and a practical tradition of instrument making. In the second half of the sixteenth century these links developed in a series of centres throughout Europe, notably, Florence, Kassel, Antwerp, Prague, and Dresden.

By the 1590s the close connections between instruments for surveying and methods for representing the physical world become more evident in treatises such as Levinus Hulsius' *Book on the Geometrical Quadrant* (1594)[28] and explicit in his *Treatise of Mechanical Instruments* (1604), which shows a perspective window being used in the field to copy the image of a fortified town on a nearby hill.[29] In 1598 Amboise Bachot describes an instrument to guide persons curious about geometry in perspective in architecture and fortifications.[30] A treatise of Johann Faulhaber (1610) shows a soldier using a perspectival window to copy a battle scene.[31] On the columns to the left and right we see a sector and reduction compass, universal measuring instruments used for both surveying and perspective. The accurate measurement of space and the realistic depiction thereof now go hand in hand.

On the title page of the mathematical works of Samuel Marolois (1614) treating geometry, perspective, architecture and fortification there are engravings of four individuals: Euclid, Archimedes, Vitruvius, and Witelo (Vitellius). Euclid is shown, (anachronistically) wearing glasses, and using a sector with various other surveying instruments lying at his feet. In the Practical Perspective of father Dubreuil (1642-1647) there is a clear engraving of an artist using a perspectival window to copy a townscape. In the *Treatise on Perspective* (1648) of Abraham Bosse, we find surveying linked explicitly with perspectival representation of a house and garden as if this were entirely natural. A complete synthesis of two traditions has taken place:
a) the use of perspective for depicting space in idealized narratives especially in religious contexts and b) the use of perspective for measuring physical space.

## 8. Conclusions

In the legal tradition there is a well-known expression: post hoc ergo propter hoc. In the realm of historiography there is also a tendency to imagine that things which happened later were the cause of that which happened previously. As we have shown, by the seventeenth century there was a close connection between a) surveying of two and three dimensional objects and surfaces; b) representation thereof using perspective of two and three dimensional objects; c) their careful measurement using d) (universal) measuring and drawing devices such as the sector and proportional compass.

In the latter nineteenth century neo-Kantians such as Cohen drew attention to the history of space and the representation thereof.[32] This led to the work of Ernst Cassirer and Erwin Panofsky, whereby world-views, theories of vision and theories of representation were theoretically linked. The history of perspective thus emerged as a symbolic form. In addition it became seen as one of the keys to understanding the rise of early modern thought and in particular early modern science.

Scholars thus began searching for an event with which to link this shift. In the second half of the twentieth century Brunelleschi's panel of the Baptistery of San Giovanni in Florence seemed suited to become such an event. In the mind of scholars such as Edgerton, Brunelleschi (c.1415-1425) became associated with other key moments such as Columbus' discovery of America (1494), the publication of Copernicus' treatise (1543) and Galileo's work (e.g. 1632). Gradually these events over two centuries became associated with a single moment in the second decade of the fifteenth century: Brunelleschi and the discovery of perspective became a symbol for the world-view of early modern science.

As we have shown the full story is much more complex. There were effectively two parallel lines for the development of perspective. One, deriving from surveying propositions within Euclid's *Optics,* was linked with the quantitative measurement of physical objects and landscapes. A second, connected with the representation of space was particularly concerned with the representation of metaphysical space especially within the Christian narrative tradition. In the case of individuals such as fourteenth century (Giotto, Lorenzetti) and fifteenth century figures (e.g. Serlio) there is evidence that they were active on both fronts. Noteworthy, however, is that their activities with respect to the measurement of physical space were not applied directly to their representation of metaphysical space.

We have shown how these parallel strands become more accentuated in the fifteenth century. In the first half (1400-1450) there is linear perspective in Italy and not in the North, yet it is in Northern Europe that there is a greater commitment to representing physically recognizable places. Notable, in this context are the Brothers Limbourg (1413-1416), who introduce a number of clearly recognizable places and churches without a commitment to even proto-perspectival methods. In the second half of the fifteenth century, the two traditions begin to overlap more clearly and yet it is not until the sixteenth and seventeenth centuries that this link between perspective and physical reality emerges clearly. Far from being a sudden revolution, linear perspective emerges in the course of nearly four centuries and leads to a parallel development of both ideal and real cities. The ideal city of the Renaissance, so famous through the Baltimore, Urbino and Berlin panels,[33] comes long before the depiction of the physical cities of Braun and Hohenberg.

If this reassessment of the early history of perspective seems curious and unlikely it is useful to examine developments within new media in the past decades. In the minds of many, the rise of computers and more specifically, Computer Aided Design (CAD) and Geographical Information Systems (GIS) represent a revolution which has many parallels with the advent of perspective in the Renaissance. Michael Giesecke,[34] the author of a standard book on the history of printing has explicitly examined these parallels. On the surface, this would lead us to expect that the new media would lead to a representational conquest of physical space at a new level. In fact, the best selling computer game thus far, *Myst*,[35] takes players into a world of the imagination, representation of an ideal, metaphysical world, rather than a simple copy of the physical world. The quest for *imago urbis* is much more than a photographic record of physical space. It is a quest to explore the realms of the imaginary: the real and ideal are inextricably linked.

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**Notes**

[1] For a standard treatment see Edgerton, Jr., The Renaissance Rediscovery of Linear Perspective. Cf. Stumpel, *The Province of Painting. Theories of Italian Renaissance Art*. Particularly "Grounds and backgrounds. Some remarks about composition in Renaissance Painting," pp. 131-172; "Perspective's veil. On the composition of storie and Alberti's theory of the artificial image," pp. 174-230.

[2] For a discussion of the connections between perspective and Christian narrative see the author's : "Narrative, Perspective and the Orders of the Church", *I Meeting Siena-Toronto*, Atti, [*Acts of Meeting in celebration of the 750th anniversary of the University of Siena*, 1991, Siena], ed. S. Forconi, Siena: Edizioni Alsaba, 1993, pp. 123-162.

[3] Theisen, Mediaeval Tradition of Euclid's Optics, p. 44:
"Their inclusion in this work is therefore most significant since these propositions add a quantitative dimension to what is otherwise a purely qualitative work on vision."

[4] Alfarabi, Opera Omnia, 1638, p. 19:
docet eciam deprehendere altitudinis arborum, turrium, parietum et latitudinis fluviorum et profunditates et altitudines moncium postquam cadit visus super fines eorum, deinde elongaciones corporum celestium et quantitates eorum.

[5] Veltman, Renaissance Optics and Perspective, pp.

[6] Cf. Veltman, The Literature of Perspective, See:
http://www.mmi.unimaas.nl/people/Veltman/books/vol3/ch1.htm

[7] Cesar Cesariensis de Prospectiva Scolia, in: Prospectiva communis, Milan: Petrus de Cornero, 1482-1483, fol. Ac2r (Milan, Biblioteca Ambrosiana, Inc. 1105. Reproduced in Catalogue: Zenale e Leonardo a Milano, 1982, p. 165.

[8] Di Giorgio Martini, Tratatti di architettura, vol. 1, f.33, Tav. 61

[9] See: gallery.euroweb.hu/.../giotto/ assisi/upper/legend/scenes_1/

[10] gallery.euroweb.hu/tours/ giotto/peruzzi.html

[11] Cf. Corboz, De l'iconographie du temple, 2001, pp.389-399.

[12] Averlino, Trattato di architettura, 1972, vol. 1, Tav. 134 (f.178v).

[13] Cf. Aronberg Lavin, Place of Narrative, 1990; Roettgen, Italian Frescoes, 1996-1997, 2 vol.

[14] Fouquet, Etienne Chevalier, Plate 16.

[15] Fouquet, Etienne Chevalier, Plates 19, 23.
See: http://www.cdrummond.qc.ca/cegep/philo/intro.htm

[16] Fouquet, Etienne Chevalier, Plate 39. Cf. Fouquet, Chroniques de Saint-Denis .
See: http://digilander.iol.it/capurromrc/!4iledelacite.html

[17] Cf. Meckseper, Kleiner Kunstgeschichte der Deutschen Stadt im Mittelalter.

[18] See: http://lcweb.loc.gov/exhibits/vatican/arch.html

[19] http://www.language-culture.org/images/photos/Euclid-optics.gif

[20] Androuet Du Cerceau, Partim a me inventa, partim ex vetarum sumpta mmonumentis tum Romae tum alibi etiam num extantibus…

[21] De Jode, Ruinarum variarum, [Antwerp], 1550. Cock, H., Praecipuae aliquot antiquitatibus ruinarum monimenta, 1551; Vredeman de Vries, Scenographiae, 1560; Pittoni, Praecipua aliquot, 1561; Blum, Wunderbarliche köstliche Gemält, 1566; Stoer, Geoemtria et Perspectiva., 1567.

[22] Braun, G.; Hohenberg, F., Civitates orbium Terrarum, 1572.
[23] See: http://www.mmi.unimaas.nl/people/Veltman/books/vol3/ap5.htm#6
[24] See: http://www.mcad.edu/AICT/images/medieval/GT/512/010.jpg
[25] The Sketchbook of Villard De Honnecourt, fol. CXL.
[26] Links, Townscape Painting and Drawing, pp. 84-85.
[27] Lantieri, Due dialoghi…1567.
[28] Hulsius, L., De quadrante geometrico libellus, 1594
[29] Hulsius, L., Traktat der mechanischen Instrumenten, 1604, p.82
[30] Bachot, A., Le gouvernail, 1598.
[31] Faulhaber, J., Neue Geometrische und Perspectivische Inventiones, 1610. Frontispiece.
[32] "Panofsky's Perspective: a Half Century Later," *Atti del convegno internazionale di studi: la prospettiva rinascimentale, Milan 1977*, ed. Marisa Dalai-Emiliani (Florence: Centro Di, 1980), pp.565-584.
[33] Cf. Herbert Damish, L'Origine de la perspective, Paris:Flammarion, 1993; *The Origin of Perspective*. Translated by John Goodman. Cambridge, Mass.: MIT Press, 1994.
[34] Michael Giesecke, Der Buchdruck in der frühen Neuzeit. Eine historische Fallstudie |ber die Durchsetzung neuer Informations- und Kommunikationstechnologien, (Frankfurt am Main: Suhrkamp, 1991).

[35] Cf. http://www.cnn.com/TECH/9710/31/riven/