Love and Measurement: Early Renaissance Painting

(sessions one and seven):
an annotated extract from the work of Martin Kemp
annotated by Allen Fisher

[The invention of linear perspective in or before 1413 by Filippo Brunelleschi, and the new attentions to proportion in Italian and Northern European painting in the fifteenth century, provided practitioners with new tools for practice, thought and persuasion. The success of this invention and these new attentions were made more efficacious by the continued regard given to the effects and representations of desire and love. What follows is a brief annotated extract from *The Science of Art* by Martin Kemp.[1] The idea of using the extract is to advance an initial understanding from Kemp of how these new tools for measurement were varied and not made exact. The idea in the following session will then be to understand how love, the second theme of these sessions, informed a flexibility that contributed to the most successful art of this early period of the Renaissance and the High Renaissance that followed. The main visual attention in this extract is the *Last Supper* by Leonardo da Vinci.[2] Square brackets in the text and footnotes indicate my occasional interventions.]

'There is virtually no aspect of perspective,' writes Kemp, that Leonardo da Vinci did not address. '… and most aspects were approached not just once but on many occasions and in different ways. Furthermore, since [Leonardo] regarded all the physical sciences and arts as integral components in a great continuum of causes and effects, it is difficult to say that his studies of dynamics, for example, should be excluded as irrelevant to his theories of vision.'

Kemp lists the main topics tackled by Leonardo in summary as:

(a) techniques of artists' perspective in theory and practice;
(b) the geometry of visual rays and intersection as related to questions of size, distance, etc. considering all the variables of the relative positions of the viewer, plane and object;
(c) devices and instruments connected with the study of vision and artists' perspective;
(d) the study of optics through the properties of the eye;
(e) the investigation of curiosities of vision and representation, such as anamorphic images;
(f) the problems arising from apparent contradictions between the various factors and approaches.

Kemp continues, 'I think the best way to tackle these issues is chronologically, since Leonardo began from a standpoint similar to that of Alberti and Piero.[3] He then moved progressively, though certainly not smoothly, towards a position in which a series of optical complications left him far from the painters' home ground …'

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[1] [The extract is from Martin Kemp, *The Science of Art. Optical themes in western art from Brunelleschi to Seurat,* New Haven and London: Yale University Press, 1990, pp. 44-52.]

[2] [A brief video showing this work with commentary is available online at: https://www.khanacademy.org/humanities/renaissance-reformation/high-ren-florence-rome/leonardo-da-vinci/v/leonardo-da-vinci-last-supper-1495-98]

[3] [Leon Battista Alberti published his treatise *On Painting* in 1435 and Piero della Francesca published his *On Perspective for Painting* around 1480.]

allenfisherstudio@icloud.com

'Leonardo clearly benefited from a solid training in the basic techniques of artist's perspective. The reliefs and paintings emanating from the studio of his master, Andrea del Verrocchio, exhibit a sound grasp of what by now was an established tool in any self-respecting artist's equipment in Florence.[4]

'Leonardo's own earliest known narrative painting [*The Annunciation,* ca.1472-3, now in the Uffizi Gallery, Florence] was designed in conformity with what a young artist would be expected to know about the construction of pictorial space. The tile pattern on the right of *The Annunciation,* is diagonally orientated, which gives a clear signal as to the method used, that is to say the lateral point system. [The perspective focus point in the centre of the horizon, arrived at by following the converging lines from the top of the pedestal-table and from the architectural features and the point of convergence of most (but not all) of the diagonally disposed lines implied by the tiles in the area occupied by the Virgin.]

Kemp notes that it is worth remembering 'that both Donatello and [Lorenzo] Ghiberti appear to have used this method, and that Leonardo's master was one of the sculptors who stood in direct line of artistic descent from [the work of these] men. Lines incised in the gesso priming in the now familiar manner testify to the care Leonardo has taken. For example, the square top of the pedestal of the Virgin's lectern has been subdivided so as to aid the construction of the inscribed circle and to establish the central axis of the supporting baluster.'

'It is, therefore, no surprise to find that [Leonardo's] earliest written definitions of perspective give voice to established theory. The translation from Leonardo states:

"perspective is a rational demonstration by which experience confirms that the images of all things are transmitted to the eye by pyramidal lines. Those bodies of equal size will make greater or lesser angles in their pyramids according to the different distances between the one and the other. By a pyramid of lines I mean those which depart from the superficial edges of bodies and converge over a distance to be drawn together in a single point. A point is said to be that which cannot be divided into any parts, and such a point, located in the eye, receives all the points of the pyramids"'.[5]

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[4] See particularly the relief of the *Beheadinq of S. John* for the altar of the Florentine Baptistery in Günter Passavant. *Verrocchio: sculptures, painting and drawings,* London: Phaidon, 1969, p. 183. and the *Madonna in front of a Ruined Basilica*, National Gallery of Scotland, in Hugh Brigstocke. *Italian and Spanish Paintings in the National Gallery of Scotland,* Edinburgh, 1978. pp. 187-92.
[It is worth noting that first of all the dates for Leonardo's training and work in the studio of Vercocchio are uncertain. They are likely to be around the period 1472-76, but could be earlier. Second, it is also worth noting that many aspects of Leonardo's technique, including his underdrawing procedure and use of monochrome under-modelling, appear to originate with his master, but since Verrocchio seems to have remained primarily a tempera painter, it is proposed that Leonardo may also have spent time with the Pollaiuolo brothers in order to learn to paint in oils. See particularly Jill Dunkerton, 'Leonardo in Verrocchio's Workshop. Re-examining the Technical Evidence', *National Gallery Technical Bulletin,* Volume 32, *Leonardo: Pupil, Painter and Master,* London, 2011.]

[5] MS. A 10r in Jean Paul Richter, *The Literary Works of Leonardo da Vinci*, 2nd edn. 2 vols, London and New York, 1970, para. 52. [a copy of the first edition (1883) is available online at: https://archive.org/details/literaryworksofl01leonuoft] and Carlo Pedretti, *Commentary*, 2 vols, Berkeley: University of California Press, 1977. All subsequent references to Richter are by paragraph numbers. Reviews and anthologies of Leonardo's notes and diagrams of perspective are provided by K. Veltman, *Studies on Leonardo da Vinci, 1. Linear Perspective and the Visual Dimensions of Science and Art,* Berlin, 1986; and *Leonardo on Painting. An Anthology of Writings by Leonardo da Vinci with a Selection of Documents Relating to his Career as an Artist*, ed. Martin Kemp and Margaret Walker, New Haven, Conn., and London, Yale University Press, 1989. MS abbreviations as in Kemp and Walker.

'There are a number of drawings in [Leonardo's] earliest manuscripts which accordingly resemble the basic demonstrations in Piero's treatise and are consistent with Alberti's text. On one occasion he set himself the task …. of reversing Alberti's procedure in order to reconstruct the eye point for an already foreshortened plane. Given the measurement of the plane at the front of the picture, he showed how to establish the measured distance of any point placed on the foreshortened plane.

'Like Piero [Leonardo] tackled the question of the proportional ratios of diminution at the intersection. He conducted an incredibly persistent study of the variables of distance from eye to object and the relative distance and orientation of the intersecting plane. A typical analysis states that 'if you place the intersection one braccio [an arm's length, usually about 66 or 68cm (26 or 27 inches), but varying between 46 and 71 cm (18 and 28 inches)] from the eye, the first object, being four braccia from your eye, will diminish by three-quarters of its height on the intersection; and if it is eight braccia from the eye by seven-eighths and if it is sixteen braccia away it will diminish by fifteen-sixteenths and so on by degrees. As the space doubles, so the diminution will double.' [6] Kemp notes, 'The crucial law that emerged from [Leonardo's] analysis was that if the distance from the eye to the plane remains constant, the apparent size of the object on the plane is inversely proportional to the distance of the eye to the object. Such systems of proportional diminution convinced Leonardo that he was dealing with a form of visual harmonics in which the perspectivist forms his "intervals" in the way "the musician does with his notes".' [7]

Kemp continues, 'There are also early signs of his interest in the optical principles underlying the geometrical procedures. In what may be his earliest surviving note on perspective [ca.1483], he outlined a rudimentary eye which was specifically designed to function in accordance with the Albertian pyramid. He referred to the "crystalline humour", to the "pupil", to the transmission of images either to the "*senso comune*" [common sense] or to the "intellect", and emphasised the special directness and power of the central ray. These concepts indicate some contact with sources beyond those strictly required for painter's perspective, though the way in which he used the technical terms does not indicate at this stage any detailed mastery of the mediaeval optical science from which they were ultimately derived.'

A little later Leonardo provided an entirely adequate account [in the manner of John Pecham, the thirteenth-century, natural philosopher] regarding the infinity of visual pyramids diffused throughout the air:

> "every opaque body fills the surrounding air with an infinite number of its images, which by means of infinite pyramids infuse the representation of this body all in all and in every part. … During their concourse, although they intersect and intermingle, they are never united one with the other, and so with diminishing concourse they proceed through the surrounding air, dispersing and extending themselves." [8]

'In a closely related image [Leonardo] speaks of the radiance of light from a body as comparable to "a stone flung into water" which "becomes the centre and source for many circles".[9] This means that the apexes of pyramids of comparable 'strength' (i.e. of the same angle) will occupy the circumference of the same circle and that the 'weakening' of the pyramids will take place in a graded manner across successively wider circles.

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[6] MS A Bv (Richter 100).

[7] MS BN 2038 23r (Richter 102).

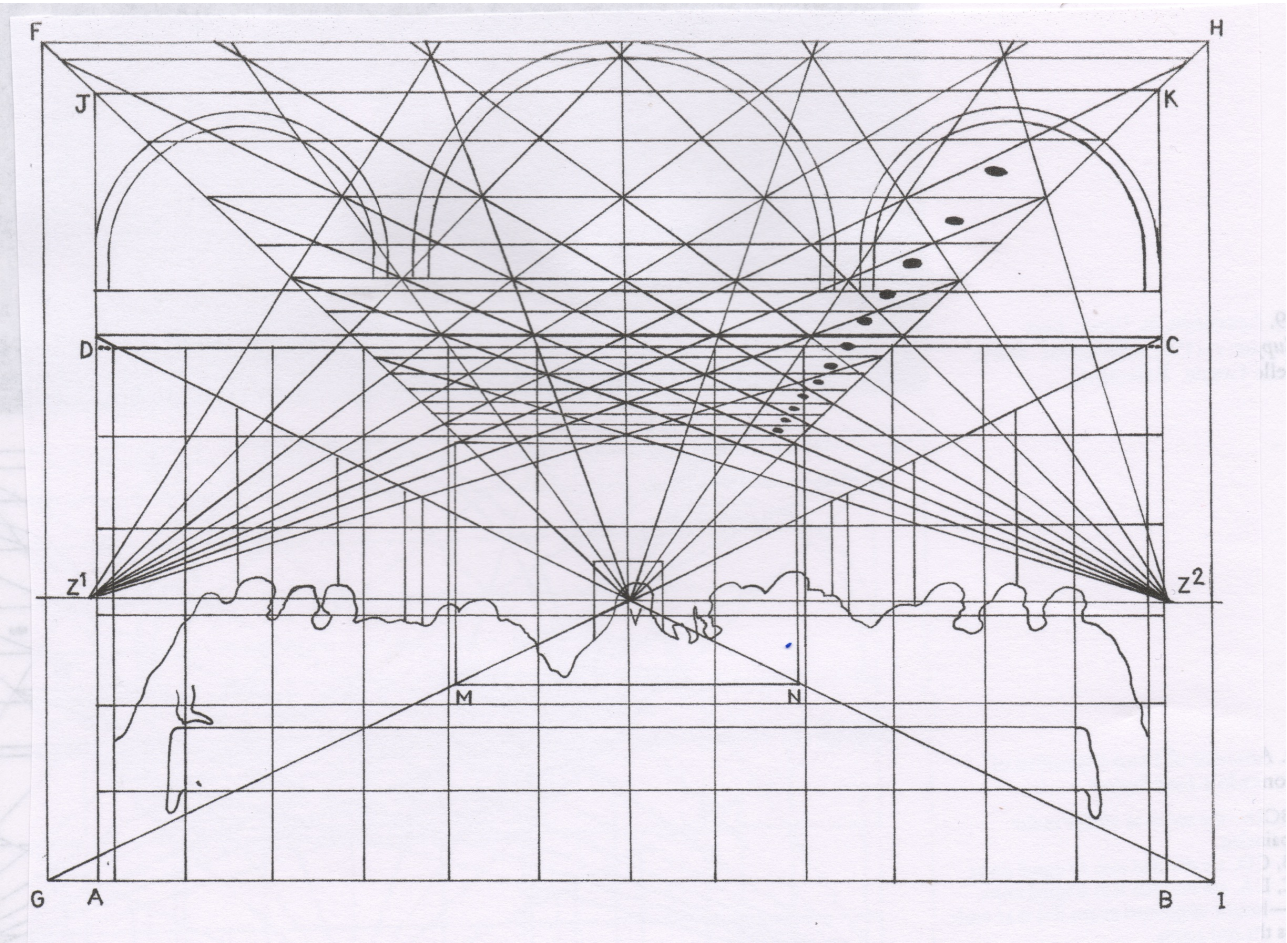
[8] MS BN 2038 6v (Richter 63). See M. Kemp, 'Leonardo and the Visual Pyramid', *Journal of the Warburg and Courtauld Institutes*, XL, 1977, pp. 128-49.

[9] MS A 9v (Richter 69).

'This pyramidal system was related by Leonardo to the fundamental law which governed the diminution of all the powers of nature. The same pyramidal law governed the diminution of sound over a given distance, the gradual draining of impetus from a moving body, and any other effects
which were subject to proportional diminution over time and distance. Gravity, by contrast, he described as operating with a reversed pyramid, bestowing extra velocity pyramidally rather than losing it.

'The height of his involvement with the analysis of the painter's pyramid came in the 1490s, during the phase of his artistic development which culminated in the *Last Supper* (ca.1497, S. Maria delle Grazie, Refectory, Milan). This painting, with its assertive recession and the system of harmonic correspondences on its surface, appears on first sight to be an uncomplicated expression of the rationality of the painters' science in the context of natural law. And, I believe, this aura of logicality is just what Leonardo hoped we would assume to be in operation. However, *closer analysis reveals a series of ambiguities and artifices which save the appearance of optical legitimacy while acknowledging the inbuilt problems and contradictions of perspectival illusion in a given situation* [my emphasis].

'It should be said at the outset that the condition of the painting makes precise analysis a perilous business. It is not possible to determine what happens at the lateral edges of the painting, where it adjoins the lateral walls, and the location of the lower margin is uncertain. The latest campaign of restoration has begun to clarify some features, such as the form of the coffers, but also confirms that crucial aspects of the construction are irredeemably lost. The second point to be made at the start of [Kemp's] analysis is that Leonardo's construction is designed not to declare itself in an overt and unambiguous manner. However, I think we can gain some idea of Leonardo's likely procedures, bearing in mind the techniques available to him.



'The coffered ceiling, like the tiled floor of Piero's *Flagellation* or the vault of Masaccio's *Trinity*, provides the obvious key to the description of the space, but it is visually isolated from the upper and lateral boundaries between the real refectory and the painted room. The ceiling does not join the picture plane at the bottom of the painted cornice, DC [in Kemp's diagram] but presumably passes behind the screen of lunettes to a level at which it abuts the wall plane.

'Precisely to what level the coffered ceiling should be extended is not explicit. If its lateral edges are extended to meet the lateral margins of the painted surface at J and K — giving a continuity between the walls of the real and painted rooms — the ceiling stops at an awkward level in relation to the lunettes and near the middle of a coffer. If, alternatively, the ceiling is extended to the height of the central lunette the lateral edges of the painted room, FG and HI, will be wider than the actual
refectory. In this second scheme, thirteen coffers will be accommodated, allowing for a strip at the top to accommodate the depth of the painted screen. Neither solution is entirely comfortable. The tidiest solution would be to assume that the ceiling is six coffers wide and twelve coffers deep, but this can only be reconciled with the first alternative if we suppose that the remainder of the "last" coffer is taken up by the depth of the painted screen plus an additional band of moulding.

'In either case, the reconstruction of the painted space is further complicated by the question of the shape of the coffers. If the coffers are square — as we tend to assume —the room would be at least twice as deep as it is wide. This would incongruously mean that the tapestries become progressively wider to a considerable degree in the deeper parts of the room.

'If we approach the question of coffer shape from a different direction, a different result is suggested. If we draw diagonals through the coffers … we will find that diagonals through pairs of coffers in depth will focus on lateral ("distance") points at Z^1 and Z^2 close to the margins of the fresco. These points would, in the traditional manner, provide a convenient means for carrying out the construction on the actual wall surface. This device of diagonals through two coffers — analogous to the systems suggested for Donatello's *Feast of Herod* [1423-7, Cathedral Baptistery, Siena] and Ghiberti's *Story of Jacob and Esau* [ca.1435, East Doors, Baptistery, Florence] — would imply that each coffer was intended to be half as deep as it is broad. This would in turn correspond to a 90° viewing angle, a viewing distance equivalent to half the width of the wall, and a painted room that is either square or slightly over square.

'There is no certain method of choosing between the alternatives. Two recent computer reconstructions of the painted space have favoured different alternatives, confirming that different solutions can achieve a fair measure of internal consistency without necessarily being susceptible to precise proof.[10]

'The problems presented by the *Last Supper,* so analysed, might lead us to wonder whether we are asking a question which the painting was not designed to answer.' Kemp suspects 'that the perspective was designed by Leonardo specifically as a *pictorial* effect within the composition as a whole in its particular setting. [Leonardo's] notebooks indicate his growing awareness of the vulnerability of orthodox perspective, particularly on a large scale and with relatively close viewing distances. His decision to isolate the coffers in a spatial "island" and his unwillingness to spell out too specific a relationship between the real and painted

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[10] D. Marini, *An Analysis of Leonardo da Vinci's 'Last Supper'*, Harvard Univ. Graduate School of Design,1982; See also M. Kemp, *Leonardo da Vinci. The Marvellous Works of Nature and Man,* London and Cambridge, Mass., Dent, 1981, pp. 194-9; P. Steadman in *Leonardo da Vinci,* ex. cat., Hayward Gallery, 1989; F. Nauman, '"The construzione legittima" in the Reconstruction of Leonardo da Vinci's *Last Supper*', *Arte Lombarda*, LII. 1979, pp. 63-9: and Giovanni Degl' lnnocenti in Carlo Pedretti, *Leonardo Architect,* London: Thames & Hudson, 1986, pp. 283ff. [Also see Matthew Landrus. 'The Proportions of Leonardo's *Last Supper*', *Raccolta Vinciana*, 32 (December 2007), pp. 43-100.]

architecture may indicate his desire to minimise the vulnerability of his illusion when viewed from different viewpoints. In other words, *Leonardo has used perspective for pictorial suggestion rather than absolute definition* [my emphasis]. The perspective is, therefore, just one of a series of compositional devices. Another device is the 6 X 12 grid of squares, which seems to provide the surface location for a number of the major elements, including the rear of the ceiling itself.

'Within his slippery set-up, Leonardo has given free reign to other ambiguities, most notably the impossibly crowded overlapping of the figures behind the table — where could they all sit? — and the undefined relationships between the seats at either end of the table and the side walls. The sum total of the ambiguities is of a quite different order than that used by Piero and Domenico Veneziano [For example in Piero della Francesca's *Resurrection of Christ,* ca.1465, Palazzo Communale, Borgo San Sepulchre and Domenico Veneziano's *St. Lucy Altarpiece,* c.1444, Uffizi Gallery, Florence.]. Their pictorial spaces are predominantly logical and at the same time play upon surface conjunctions. Leonardo's space looks logical but actively resists unequivocal translation into an actual space.

'The factors which led him to subvert the rationality of painter's perspective resided both within the system itself and in its relationship to physiological optics.' Kemp first looks at the internal factors.

'Working on such a scale in a particular building, he clearly became acutely conscious of the problem of viewpoint. Theoretically, the painting should be viewed from one ideal position. By placing the viewpoint at the level of the heads within the painting, which obviously makes good sense in telling the narrative, he has already conceded that the spectator will not be viewing his illusion from the ideal position, since this position is located at more than twice the height of an
average person. As the spectator — and, we may imagine, Leonardo himself — moves around the refectory, so the picture plane itself distorts perspectivally, with a corresponding effect on the foreshortened objects in relation to the real space. He has done his ambiguous best to preserve the illusion, but even he must admit ultimate defeat.

'There is clear evidence in his notebooks at this time that he was beginning to undertake an analysis of such problems, and that his analysis led him to distinguish between two main types of perspective; 'artificial perspective' (prospetriva accidentale) "which is made by art" and consists of the painter's projection of forms on to a plane which is itself liable to foreshortening; and "natural perspective" which concerns the perception of the relative sizes of actual objects in nature.[11] The difference revolves around the Euclidian question of visual angles. The problem, stated briefly, runs as follows. If the eye looks at a series of objects of equal size distributed at equal intervals along a plane perpendicular to our axis of vision, the visual angles under which the objects and intervals are seen will progressively diminish at points towards the extremities. Thus the more remote objects will be seen as smaller.

'Diagrams relating to this problem appear in [Leonardo's] drawings during the 1490s, and perhaps earlier. In these he takes a "curved plane" (not a "curved wall" as sometimes translated) as defining when the forms are equidistant from the eye in "natural perspective" and, therefore, when they will appear the same size.' [12]

Kemp is saying 'that Leonardo is not openly advocating that the painter should adopt the practice of curvilinear perspective, nor is he demonstrating that the painter's construction is necessarily invalid. [Leonardo] is saying that when the painter's representation of forms on a flat plane … is viewed from anywhere other than the perfect point — ideally "through a hole" — it will fail to act in a manner consistent with natural perspective. The problems become particularly severe for forms seen at the extremities of wide

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[11] MS A 38r (Richter 36), M2 81r (Richter 91), A 41r-v (Richter 544-5).

[12] H' 321' (Pedretti, *Commentary*, 1, p. 141).

angles.[13] When he suggests, much later in his career, how the painter might represent the lateral diminution of a wide object he proposes not a curvilinear recession but one in which two lateral points of rectilinear convergence result in a "hexagonal figure" …'

'By this later stage he has organised his thoughts systematically and defined the various kinds of perspective. Two of these, "natural" and "artificial", we have already encountered. The third is "compound perspective", which relies upon a combination of foreshortening on the plane and the foreshortening of the plane itself. In paintings such as the *Last Supper* this compound effect is nothing but a nuisance, and from extreme angles "all the depicted objects will look rnonstrous".[14] But the artist can also exploit compound perspective to his own advantage, through what we now call anamorphic images. In this composite system, the projection on the picture plane is systematically distorted so that it will look bizarre or even illegible from head on, but will assume proper proportions when viewed at an angle which foreshortens the picture plane itself to the appropriate degree [that is anamorphic]. Leonardo appears to have been the earliest promoter of this visual trick, though, … Piero della Francesca was aware of its principles. Towards the end of his career Leonardo made a pictorial demonstration of anamorphosis for Francis I in the form of a painting of a dragon fighting a lion.[15]

'Anamorphosis remained more in the nature of a visual game than a method which could be widely used in normal circumstances. It shared the chief disadvantage of one-point perspective, namely its reliance upon a single viewing position, and actually worked less well than orthodox perspective from less than perfect viewpoints.

'A related technique which Leonardo was also considering did prove to have a more serious, regular application. This technique provided a way of projecting an object on to more than one plane or on to curved planes in such a manner that the distinctions between the planes or their surface configurations appear to dissolve. He explains how "to make a figure which declares itself to be forty *braccia* high in a space of twenty *braccia*", by projecting the figure on to two planes at right angles, such as a wall and ceiling, or on to the curving plane of a vault." [16] [Leonardo's] accompanying diagram only indicates half the necessary procedure but the principle is clear enough and is in essence the first record of a technique which was to be followed by generations of illusionistic decorators from the mid-sixteenth century onwards.

'This technique, like all the others, would be vulnerable to changes of viewpoint. The best Leonardo could do was to minimise and disguise the most directly vulnerable elements, as in the *Last Supper,* or advise the painter to ensure that each picture works reasonably well from a distant viewpoint, since changes in the viewer's position will then have relatively little effect on the shape of the picture plane.[17] However, even if these expediencies are adopted, he acknowledged that there remain a series of factors which further erode the "naturalness" of the painter's system.' Kemp gives three examples. 'The painter cannot cope with binocular vision. The representation of transparent or nebulous forms, such as water and smoke, lies outside the system of linear perspective. Colour and tone will affect our subjective appreciation of size and distance.[18]

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[13] E. 16r (Richter 108).

[14] B L 66r (Richter 109).

[15] Pedretti, *Commentary*, I, pp. 149-50.

[16] A 38v and *Codex Urbinas* 139v—l40r (Richter 526). See also *Treatise on Painting* by Leonardo da Vinci, ed. A. Philip McMahon, 2 vols, Princeton. NJ.: Princeton University Press, 1956, para. 497.

[17] A 41v (Richter 545).

[18] For an outline of these problems, which warrant further analysis. see Kemp, *Leonardo da Vinci*, pp. 331ff. A group of relevant texts is provided by Richter, 39-62.

The more Leonardo studied the visual world, the more such problems of perception asserted themselves.

'All these problems may be seen as qualifications or limitations to be acknowledged in the theory and practice of painters' perspective. But there was an even more fundamental difficulty, which arose from the physiology of vision as then understood. The prevailing view of the eye in the sources available to Leonardo was that it consisted of a complex series of spheres and part-spheres which were designed to refract the incoming light rays in such a way as to produce an upright simulacrum of the seen object at the seat of the visual power.[19] This system was at variance with the pyramids of Alberti, Piero and early Leonardo, which actually converged to a
point. Leonardo, as we have noticed, even characterised the point as specifically mathematical, i.e. having no dimension.

'During the 1490s [Leonardo] gained a closer acquaintance with standard optical texts. He quoted at length from Pecham, in praise of optics … and he began to realise the contradiction.[20] By 1507-8 when he came to compile his short manuscript treatise "On the Eye", [Leonardo] was able to state confidently that "it is true that every part of the pupil possesses the visual power, and that this power is not reduced to a point as the perspectivists wish".[21] The Albertian pyramid is not, therefore, a physical reality. Indeed, Leonardo's pattern of rays in the eye involves a complex double inversion — one occasioned by the camera obscura effect of the pupil and the other required to reinvert the image.

'This revision in itself would not be too problematical for the painter, since we have seen that the mediaeval theories envisaged the refracted pyramid measuring visual angles as if the rays converged to an *imagined* or notional vertex. The real difficulties arose from the fact that rays from the same parts of the object would reach different parts of the visual power and vice versa. The geometrical simplicity of the canonical pyramid was disrupted. According to the pyramidal theory, near forms occluded remoter objects in an absolutely straightforward manner. However, according to his later theory, no edge will ever be seen absolutely, and no object near the eye will occlude distant objects in a totally clear-cut manner. This theory also seemed to explain why a very small object close to the eye appears to be translucent, and why we are able to see relatively well through an open-weave cloth held near the eye.

'This optical system is logical enough as a consequence of the supposed anatomy of the eye, and bore some relationship to Leonardo's revered "experience". However, he was some way from anticipating Kepler's idea of an inverted "picture" which is focussed on the retina, and no amount of juggling with quotations from Leonardo's notebooks will prove otherwise. Given the logical consequences of his opthalmology he was honest enough to admit that they caused more problems than they solved for the perspectivist. He did not throw the pyramid overboard altogether, and recognised that it retained its sphere of valid if limited operation as *prospecttiva accidentale,*
though it had lost its centrality and infallibility. His own later paintings contain no overt displays of linear perspective, even in the compromised manner of the *Last Supper*. Although the subjects of these later paintings do not particularly lend themselves to architectural perspective, it is significant that they are

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[19] In addition to Kemp (n. 91), see J. Ackerman, 'Leonardo's Eye', *Journal of the Warburg and Courtauld Institutes*, XLI. 1978, pp. 108-46, and, more generally, David C. Lindberg, *Theories of Vision from al-Kindi to Kepler,* Chicago and London: University of Chicago Press, 1981 (11. 24). An excellent review of this problem is now provided by Bruce Eastwood, 'Alhazen, Leonardo, and late-Mediaeval Speculation on the Inversion of Images in the Eye', *Annals of Science*, XLIII, 1986, pp. 413-46.
[See also Sven Dupré, 'Optics, Pictures and Evidence: Leonardo's Drawings of Mirrors and Machinery', Early Science and Medicine, Vol. 10, No. 2, Optics, Instruments and Painting, 1420-1720 Reflections on the Hockney-Falco Thesis (2005), pp. 211-236.]

[20] *Perspectiva communis*, 1, i (n. 24), and Kemp (n. 91), pp. 132-3 and 135-7.

[21] MS. D43 (and related texts in Kemp, (n. 91), p. 138, n. 38).

characterised by optical qualities of a very different kind — softly veiled distances, fluid transitions of form, blurred contours and horizons that refuse to be simply horizontal.

'When we look at his later drawings we see correspondingly fluid visions of form in motion and of mobile viewpoints. He developed a remarkable sense of the continuity of forms in space — a vision which was nourished by the traditional concept of "continuous quantity", which served to differentiate geometry from the discontinuous terms of arithmetic — and he devised systems of illustration in which forms are depicted as rotating in front of our eyes. In a complementary manner, he also depicted figures themselves in local movement, as he who most completely realised and investigated the multi-faceted nature of Brunelleschi's invention. And, like his greatest predecessors, he did not so much add science to art, or even art to science, as show how the 'science of art' possessed a creative unity of its own special kind in relation to both form and content. … All his predecessors had, to their own satisfaction, at least, isolated what they considered to be the salient factors in the analysis and construction of space. This concentration of ways and means had been accomplished by emphasising the mathematics of the intersection largely at the expense of the physiology of vision. … Leonardo's sheer comprehensiveness and persistence laid bare the series of tensions and contradictions which were implicit from the first in
the painter's new technique….'