

graphic qualities, cannot be redrawn because, as shown previously, it illustrates an impossible solution. This is a «beautiful false» drawing.

When historians of art and science confront «beautiful false drawings» and «ugly true diagrams», they are likely to form different judgments, for aesthetic qualities recede into the background in the judgment of the historian of science, while prevailing over truthfulness in that of the historian of art. Accordingly, there are two independent orders of values. But precisely for that reason, a full recognition of Leonardo's brilliant intuitions and artistic talent is wholly compatible with the unbiased and critical assessment of his optical research.

THE MEASURE OF SIGHT
AND THE MEASURE OF DARKNESS:
LEONARDO DA VINCI AND THE HISTORY OF BLURRINESS

In the *History of Blurriness* Wolfgang Ullrich offers a number of thoughts on sharpness and blurriness—as qualities of focus within an image—that may be pertinent to our understanding of Leonardo da Vinci¹. Beginning with the photography of the nineteenth century, and thinking in terms of broader historical periods, Ullrich observes that certain phases in the history of art have prioritized sharp focus, while others have been characterized by an interest in blurred focus. Historically, sharp focus has represented the optimization of sight, a rational worldview, the mastery of nature, as well as the analysis, control and distance from the object portrayed. Conversely, blurriness came to be associated with reflexivity and auratization, referring to the sympathetic union with the subject or the metaphysical experience of seeing. In contrast, a sharp or heightened focus as the means of rendering the world more intelligible could yield insights into the metaphysical. Sharpness and blurriness, therefore, are each the object of different idiosyncrasies, and consequently, their evaluations are subject to change. The significance of sharpness and blurriness is thus continuously being renegotiated. Looking back across the course of the history of art as a whole, the two positions can claim neither absolute exclusivity nor a normative binding status.

¹ W. Ullrich, *Geschichte der Unschärfe*, Berlin 2002. This paper was delivered as a twenty-five minute lecture, and I have not tried to disguise the informality of the spoken word. Parts of the arguments in this text have already been published in my essay «Die Geburt der Wissenschaft aus dem Geiste der Kunst», in: *Leonardo da Vinci. Der Codex Leicester*, Düsseldorf 1999, pp. 15-31, and in my book *Bewegung und Ausdruck bei Leonardo da Vinci*, Leipzig 2010, pp. 253-277 (especially on *aria* and *sfumato*).

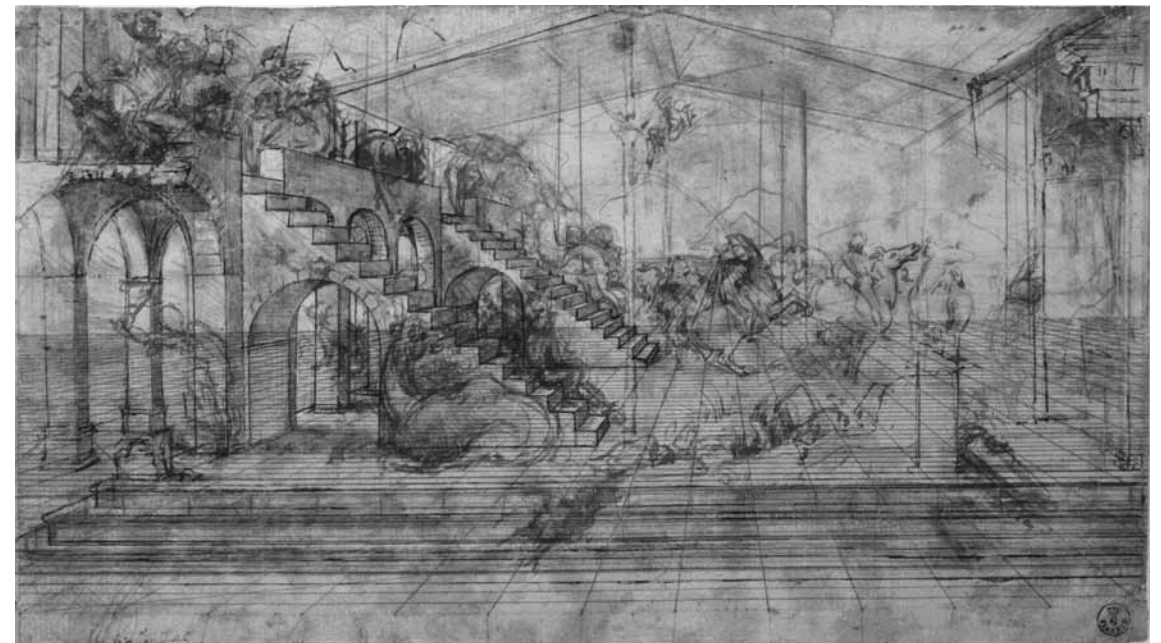
What can generally be observed for the history of art can be applied equally to individual cases.

Such a shift in priority from sharpness to blurriness sometimes also occurs within the oeuvre of a single artist. Sharpness is typically the priority at the start of an epoch, analogous to the early stages of an artistic career; blurriness is often the priority at the end. Leonardo da Vinci is a case in point. In his early work, Leonardo tends toward sharpness, the delineation of objects and the rational construction of spatial depth through perspective. In the years after 1500, we observe an increasing tendency towards blurriness and a suggestive evocation of space achieved with *sfumato*, a technique that remains Leonardo's trademark. The stages and problems of this development are well known and have been dealt with more competently by many experts, and so, only a brief summary will follow².

The artistic principles of perspectivity and linearity, in the sense of a linear style, are particularly evident in Leonardo's early work. For example, in his Uffizi *Annunciation*, he deliberately introduces a window into the side-wall, producing an ambitious perspectival construction (fig. 1). The earlier, standard solution lacks a window, now evident from x-rays and visible in a fresco from Ghirlandaio's workshop in San Gimignano³. Perspectivity is also characteristic of Leonardo's initial ideas for the composition of the *Adoration of the Magi* (fig. 2). An elaborate perspectival construction seems to have

² See most recently (and with references to the older literature) K. H. Veltman, *Studies on Leonardo da Vinci I. Linear perspective and the visual dimensions of science and art*, Munich 1986, pp. 378-456; F. Fehrenbach, «Der oszillierende Blick. *Sfumato* und die Optik des späten Leonardo», in: *Zeitschrift für Kunstgeschichte*, 65, 2002, pp. 522-544; J. Bell, «*Sfumato* and acuity perspective», in: *Leonardo da Vinci and the ethics of style*, ed. by C. Farago, Manchester 2008, pp. 161-188; F. Fiorani, «The colors of Leonardo's shadows», in: *Leonardo. The International Society for the Arts, Sciences and Technology*, xli, 2008, pp. 271-278; Ead., «The shadows of Leonardo's *Annunciation* and their lost legacy», in: *Imitation, representation and printing in the Italian Renaissance*, Pisa 2009, pp. 119-156. For general relation to sixteenth-century theory see T. da Costa Kaufmann, «The perspective of shadows: The history of the theory of shadow projection», in: *Journal of the Warburg and Courtauld Institutes*, xxxviii, 1975, pp. 258-287, pp. 271-275 on Leonardo.

³ See *L'Annunciazione di Leonardo. La montagna sul mare*, ed. by A. Natali, Milano 2000 [2001], pp. 47-50 and figs. 14-15, and pp. 113-115; F. Zöllner, *Leonardo da Vinci. The complete paintings and drawings*, 4th rev. ed., Cologne 2012, cat. no. V, p. 216 (pages and chapters are identical with the 1st ed., Cologne 1998, and with later editions).



1. Leonardo da Vinci, *Annunciation*, oil and tempera on poplar, ca. 1473-1475, Florence, Galleria degli Uffizi

2. Leonardo da Vinci, *Drawing for the Adoration of the Magi*, pen and ink over metal point, 1481, Florence, Galleria degli Uffizi, Gabinetto dei Disegni e delle Stampe

originally filled the background, which he then substantially simplified in the actual painting (fig. 3). In contrast to the *Annunciation*, he opted to replace a more complex solution with a simpler one.

By all appearances, Leonardo can be seen to experiment in his early work with perspectivity and linearity with the same delight in invention characteristic of his later work. This love for experiment—this joy in the complexity of perspectival constructions—possibly reaches its peak in the *Last Supper* (fig. 4). There have been several scholarly attempts to demonstrate the existence of a highly elaborate system of perspective in Leonardo's Milanese fresco⁴. However, it might also be argued that the *Last Supper* in its final form represents an early attempt to simplify the complexities of perspective. This issue has yet to be fully resolved. Disagreement continues to surround the extent to which Leonardo modified, in the course of painting, the original perspectival construction and whether these modifications followed exact and decipherable laws of proportion⁵. The scored lines of the perspective construction, brought to light by the most recent restoration of the fresco, have suggested to some that Leonardo was aiming for a specific proportional relationship between individual sections of the construction (fig. 5). It might also be suggested that the variant perspective lines discernible in the ground of the painting create an improvised adjustment to its original, rigorous construction. In this case, it is not a heightening of the complexity of the perspective system, but a spontaneous change towards simplification⁶.

Yet, these scored lines, along with the theoretical reflections on perspective demonstrate that Leonardo was intensively preoccupied with the proportionality of perspective and the rational aspect of sight, indeed in the measure of sight. It is this scientific interest, and in particular Leonardo's views on the proportionality of perspective, to which this essay now turns. In several observations made during the 1490s and in the period after 1500,

⁴ See for example T. Brachert, «A musical canon of proportion in Leonardo da Vinci's *Last Supper* », in: *The Art Bulletin*, LIII, 1971, pp. 461-466; G. Eichholz, *Das Abendmahl Leonardo da Vincis*, München 1998, pp. 123-187.

⁵ M. Landrus, «The proportions of Leonardo's *Last Supper* », in: *Raccolta vinciana*, XXXII, 2007, pp. 303-355.

⁶ P. B. Barillon & P. C. Marani, *Leonardo. L'ultima cena*, Milan 1999, pp. 359-360; for further references to the perspective of the *Last Supper*, see Zöllner, 2012 (as in n. 3), cat. no. XVII; L. Steinberg, *Leonardo's incessant Last Supper*, New York 2001, pp. 153-194.

Leonardo insists that the perspective diminution of objects in nature and pictorial space followed specific laws of proportion. A select example appears in the *Manuscript A*, fol. 23r, which is incorporated into Leonardo's *Trattato della pittura* as chapter 461. In the translation by Martin Kemp and Margaret Walker, it begins as follows:

Linear perspective embraces all the functions of the visual lines, proving by measurement how much smaller the second object is than the nearest, and how much the third is smaller than the second, and so on by degrees, as far as the objects can be seen. I have found by experiment that when the second object is as far from the first as the first is from the eye, although they are the same size, the second will appear as half as small as the first. And if the third object is of equal size to the second, and the third is as far distant from the second as the second is from the eye, it will appear half the size of the second, and so on by degrees. At equal distances the second will always diminish by a half compared to the first, and so on.

If you place the intersection at one *braccio* from the eye, the first object, situated at a distance from your eye of four *braccia*, will diminish by three-quarters of its size on the intersection; and if it is eight *braccia* from the eye, by seven-eighths; and if it is at a distance of sixteen, by fifteen-sixteenths of its height, and so on from stage to stage. As the space doubles so the diminution doubles⁷.

Similar reflections on the proportionality of perspective are also found in Leonardo's later writings. At several points in his *Trattato*, he stresses that perspectivity is a means of demonstrating the scientific nature of painting and thereby may be elevated to the rank of philosophy⁸. He also compares perspective to music, where proportions are likewise responsible for harmony⁹. In the same context, he makes the point that it is precisely the musicians who classify

⁷ *Leonardo on painting: An anthology of writings by Leonardo da Vinci with a selection of documents relating to his career*, ed. by M. Kemp and trans. by M. Walker, New Haven/London 1989, pp. 119-120. This text is also available in *The literary works of Leonardo da Vinci*, ed. by J. P. Richter, Vol. 1, Oxford 1970, p. 99; and it is included in Leonardo da Vinci, *Libro di pittura. Codice Urbinat. lat. 1270 nella Biblioteca Apostolica Vaticana*, ed. by C. Pedretti & C. Vecce, Firenze 1995 [hereafter: Leonardo, *Libro di pittura*, 1995], chapter 461, with further references; see also also C. Farago, *Leonardo da Vinci's Paragone: A critical interpretation with a new edition of the text in the Codex Urbinas*, Leiden 1992, p. 98.

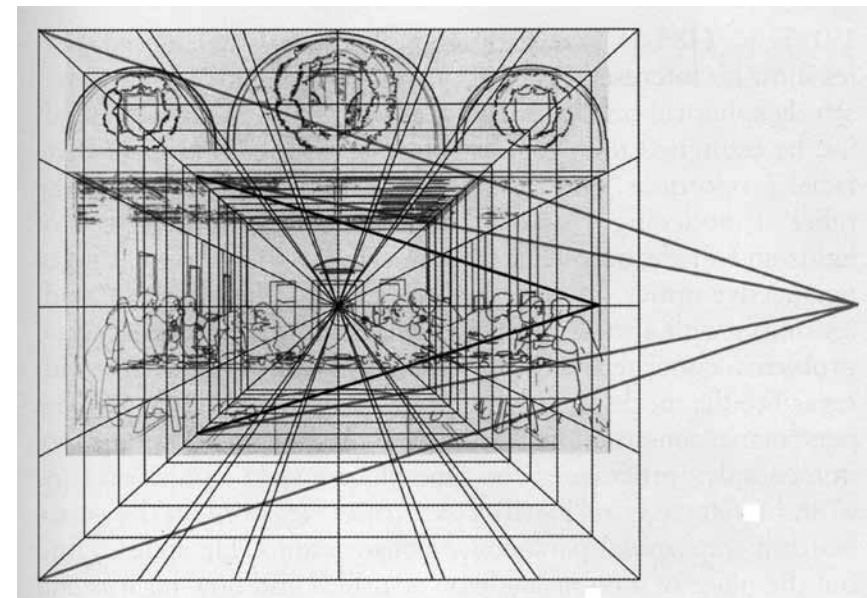
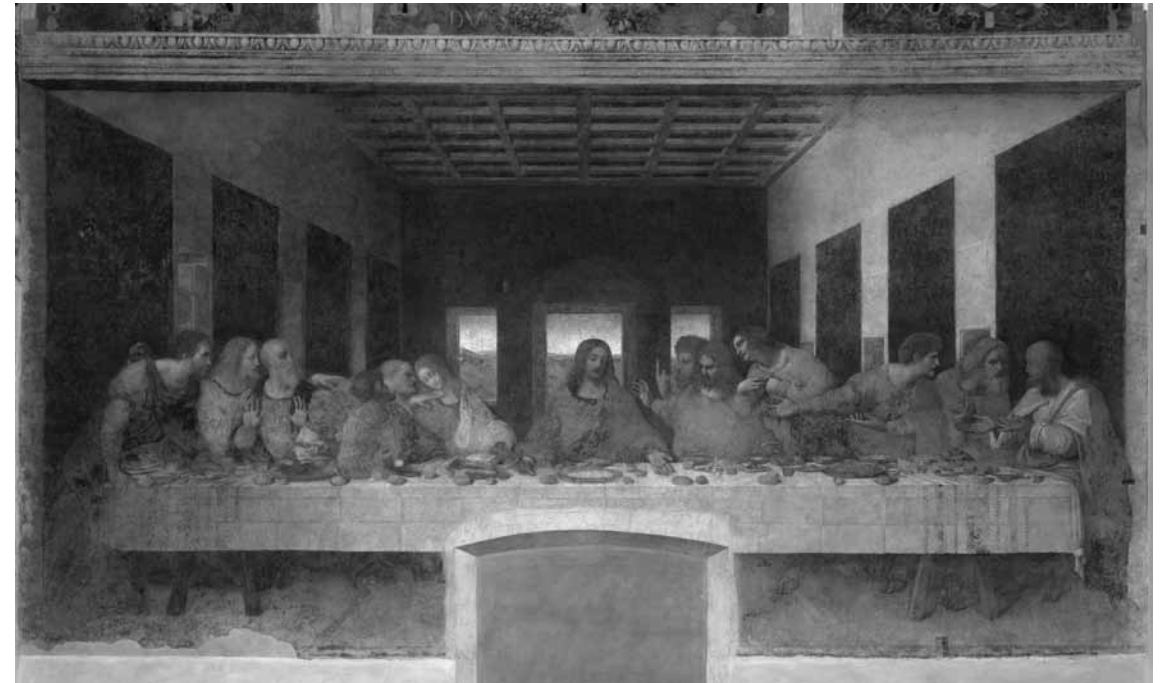
⁸ Leonardo, *Libro di pittura*, 1995, chapters 6 and 9.

⁹ *Ibid.*, chapter 31.



3. Leonardo da Vinci,
Adoration of the Magi,
oil on wood, 1481-1482,
Florence, Galleria degli
Uffizi

4. Leonardo da Vinci,
The Last Supper, oil and
tempera on plaster, ca.
1495-1497, Milan, Santa
Maria delle Grazie, north
wall of the Refectory



5. Leonardo da Vinci,
The Last Supper.
Reconstruction of
perspective after Matthew
Landrus (2007)

painting as a merely manual craft. Here we can recognize one of the motives for Leonardo's insistence on proportion and the measure of sight: the correct measure of sight and thus the rationality of perspective elevate painting to a higher status, a matter very close to Leonardo's heart in precisely these years.

Much has been written about Leonardo's thoughts on the measure of sight and the proportionality of perspective¹⁰. How his prolific ideas may be individually evaluated and whether they are right or wrong is something that, as a non-specialist, I am unable to judge. However, Leonardo's determination to establish a compelling relationship between perspective—and with it, painting in general—and measurement as a value is firmly anchored in the artistic theory of the fifteenth century. Here, the necessity of measurement and proportion in the context of perspective is expressly emphasized¹¹. Piero della Francesca had already reflected on measurement and proportion as the basis of perspective in his *De prospectiva pingendi*, when he voiced his opinion that it was impossible to have perspective without measurement, or to use his word, *commensuratione*. Only through *commensuratione*¹² and *proporzione* does perspective attain its ennobling effect. Related ideas can be found in the writings of Leon Battista Alberti and Lorenzo Ghiberti. Antonio di Tuccio Manetti expresses the same thoughts in his life of Filippo Brunelleschi, when describing the latter's perspective experiment. And Manetti's anecdote about the joint stay of Donatello and Brunelleschi in Rome follows a similar course: for sheer delight at the proportions of classical antiquity, the two artists forgot all about food, drink and even personal hygiene¹³.

¹⁰ On proportionality in perspective see R. Wittkower, «Brunelleschi and proportion in perspective», in: *Journal of the Warburg and Courtauld Institutes*, xvi, 1953, pp. 275-291; on Leonardo's ideas about proportion in perspective see *ibid.*, pp. 285-287. The importance of both the question of proportion in perspective and Wittkower's article has been stressed recently by F. Büttner, «Rationalisierung der Mimesis. Anfänge der konstruierten Perspektive bei Brunelleschi und Alberti», in: *Mimesis und Simulation*, ed. by A. Kablitz & G. Neumann, Freiburg 1998, pp. 55-87; *Id.*, «Perspektive als rhetorische Form. Kommunikative Funktionen der Perspektive in der Renaissance», in: *Bildrhetorik*, ed. by J. Knappe, Baden-Baden 2007, pp. 201-231.

¹¹ See Wittkower, 1953 (as in n. 10), pp. 276-285; Büttner, 1998 (as in n. 10), p. 75; *Id.*, 2007 (as in n. 10), pp. 209-210.

¹² Piero della Francesca, *De prospectiva pingendi*, ed. by G. N. Fasola, Florence 1942, p. 63.

¹³ Antonio di Tuccio Manetti, *Vita di Filippo Brunelleschi*, ed. by G. Tanturli, Milan 1976, pp. 67-69.

This enthusiasm for measure and proportion may be explained in terms of the desire to increase the standing of painting via the application of science. Through the rationality of measurement, fine art could also approach the *logos* and thus a more highly regarded sphere of human activity¹⁴. The Quattrocento artists and theoreticians, whose names appear above, formed part of this tradition when they conferred the status of science on painting. Thus, Alberti seeks to establish a «scientific» foundation for art in the first two books of his treatise *De pictura*. He also strives to link art to science in his treatise *De statua*, with its advice on how to measure figures, and so does Piero della Francesca in his *De prospectiva pingendi*¹⁵. Other authors honored these efforts to attain mathematical accuracy in painting by extolling painters who used dividers, rulers, geometry, arithmetic and perspective¹⁶. It was insisted that the study of the exact measurements and symmetries of classical buildings led to fame and social recognition¹⁷. Leonardo argues for the application of mathematical principles to painting as a means of raising its status. In his view, number and measure, synonymous with arithmetic and geometry, guarantee a greater degree of certainty and provide the true basis of painting¹⁸. The elevation of painting through arithmetic and geometry was still being recommended even in the sixteenth century¹⁹.

The particular zeal with which Leonardo and other art theoreticians of his epoch defended the correct measure of sight and proportionality of perspective is bound up in the high esteem enjoyed by traditional notions of

¹⁴ Philostratos the Lemnian, *Imagines*, ed. by A. Fairbanks, London/New York 1931, 1.1.

¹⁵ See Leon Battista Alberti, *On painting and on sculpture*, ed. by C. Grayson, London 1972; Leon Battista Alberti, *Das Standbild. Die Malkunst. Grundlagen der Malerei*, ed. by O. Bätschmann, Darmstadt 2000; Piero della Francesca, 1942 (as in n. 12). See also L. Olschki, *Geschichte der neusprachlichen wissenschaftlichen Literatur*, Heidelberg 1919-1927; A. Chastel, *Art et humanisme à Florence au temps de Laurent le Magnifique*, Paris 1982, pp. 96-102; Zöllner, 1999 (as in n. 1).

¹⁶ Luca Pacioli, *Summa de arithmetica, proportioni et proportionalita*, Venezia 1494, p. 1; Camillo Lunardi, *Speculum lapidum* [1502], p. xlvi, as quoted in: H. Ost, *Leonardo-Studien*, Berlin/New York 1975, p. 109.

¹⁷ Cesare Cesariano, *Di Lucio Vitruvio Pollione De architectura libri dece traducti de latino in vulgare affigurati*, Como 1521, fol. 46v.

¹⁸ Leonardo, *Libro di pittura*, 1995 chapter 33; Kemp/Walker, 1989 (as in n. 7), p. 8.

¹⁹ See A. Blunt, *Artistic theory in Italy 1450-1600*, Oxford 1940, pp. 50-52, on Mario Equicola, *Istituzioni*, 1541.

harmony, as expounded in widely disseminated religious texts (such as the Bible) and writings of classical and post-classical philosophers (such as Plato and Augustine). Ultimately, the measure of sight and the proportionality of perspective are rooted in sacred notions. In a secular world, these concepts have retained their significance in the most diverse forms of normative aesthetics right up to the twenty-first century. The fact that normative aesthetics remain a popular subject of scholarly debate, even though contemporary art thrives entirely without norms, is surely one of the most astonishing phenomena of art history.

I mentioned at the start of this essay that Leonardo's evocation of pictorial space shifts, broadly speaking, into a different technical mode following the turn of the sixteenth century. This change corresponds to a shift in other areas. Rigid anthropometry informing Leonardo's earlier studies on proportion and movement gives way after 1500 to a different approach that bases itself less rigorously on exact measurement²⁰. A similar change can also be observed in his handling of light and shade as tools for creating pictorial space. The extraordinary significance of light and shadow in Leonardo's artistic theories and painterly oeuvre was recognized even in the Cinquecento and subsequently became an object of regular discussion²¹.

After 1500, Leonardo sought to endow his painting with a new, softened outline combined with a more restrained use of local color and a more emphatic use of *chiaroscuro* modeling (figs. 6, 7). Light, shadow and color are now more closely related in Leonardo's painterly oeuvre than had previously been seen in the Quattrocento. His increased achromatic modeling of form lessened the disruptive effect of local color and polychromy, which had been characteristic of painting up to that point²². This resulted in an expressive quality that could exist independently of the actual con-

²⁰ Zöllner, 2010 (as in n. 1), pp. 123 and 155-169.

²¹ Giorgio Vasari, *Le vite de' più eccellenti pittori scultori ed architettori*, ed. by G. Milanesi, Firenze 1906, Vol. I, p. 185 and Vol. IV, col. 50; Gian Paolo Lomazzo, *Idea del tempio della pittura*, 1590, quoted in *Scritti sulle arti*, ed. by R. P. Ciardi, Vol. I, Firenze 1974, pp. 50-55, and in L. Beltrami, *Documenti e memorie riguardanti la vita e le opere di Leonardo da Vinci*, Milan 1919, pp. 191-192 and 215.

²² See J. Shearman, «Leonardo's colour and chiaroscuro», in: *Zeitschrift für Kunstgeschichte*, 25, 1962, pp. 13-47.

²³ A. Nagel, «Leonardo and sfumato», in: *RES. Anthropology and aesthetics*, XXIV, 1993, pp. 7-20; M. Barash, *Light and color in the Italian Renaissance theory of art*, New York



6. Leonardo da Vinci, *Portrait of Lisa del Giocondo (Mona Lisa)*, oil on poplar, 1503-1506 and later (1510?), Paris, Musée du Louvre

7. Leonardo da Vinci, *Saint John the Baptist*, oil on wood, ca. 1513-1516 (?), Paris, Musée du Louvre

tent of the picture²³. This advance in the representational mode of painting may be explained in part by Leonardo's awareness of the achievements of antique painters like Apelles and Parrhasius, who were traditionally credited with producing similar phenomena in their drawing of outlines and shadows²⁴. Another major contributing factor was the development of oil painting in Italy towards the end of the fifteenth century. The oil technique, with its many layers of thin, almost colorless glazes, made it possible for artists to achieve the highly expressive *sfumato*, which led to softer transitions between various parts of the picture and a more differentiated depth of shadow²⁵.

Even before the triumphal advance of oil painting, Alberti had already recommended smooth transitions between surfaces. According to his model, the creation of greater pictorial depth through the subtle gradation of shadow guaranteed harmony, grace and beauty in painting²⁶. Antique rhetoric provided a suitable comparison in this regard, for as Quintilian had already pointed out, just as the harmonious flow of speech is impeded by the disruptive effect of language, so too the grace belonging to painting may be endangered by the disruptive effect of the different colors associated with

1978, pp. 73-76; T. Puttfarcken, *Roger de Piles' theory of art*, New Haven/London 1985, p. 37; Zöllner, 2010 (as in n. 1).

²⁴ Pliny the Elder, *Natural history in ten volumes*, ed. by H. Rackham, Vol. IX, Cambridge/MA 1949, Book xxxv, 41-43; 35, 97 (*atramentum*); 35, 67-68 (Parrhasius); and 35, 131; Philostratos, 1931 (as in n. 14) 1.4; Marcus Fabius Quintilian, *Institutio oratoria*, ed. by H. E. Butler, New York 1920, Book XII, chapter 10, 4. See also Shearman, 1962 (as in n. 22); E. H. Gombrich, *Art and illusion*, New York 1960, pp. 138, 211 and 220-222; K. W. G. Posner, *Leonardo and central Italian art: 1515-1550*, New York 1974, pp. 17-22; R. Preimesberger, «Zu Jan van Eycks Diptychon in der Sammlung Thyssen-Bornemisza», in: *Zeitschrift für Kunstgeschichte*, 54, 1991, pp. 459-469.

²⁵ See C. L. Eastlake, *Methods and materials of painting of the great schools and masters*, New York 1960, Vol. II, pp. 68-124; E. Berger, *Quellen und Technik der Fresko-, Öl- und Temperamalerei des Mittelalters*, München 1912, pp. 239-284; Id., *Quellen für Maltechnik während der Renaissance und deren Folgezeit*, München 1901, pp. XII-XX; Posner, 1974 (as in n. 24), pp. 61, n. 91; M. Koller, «Das Staffelbild der Neuzeit», in: *Reclams Handbuch der künstlerischen Techniken*, Stuttgart 1988, Vol. I, pp. 261-434; R. E. Straub, «Tafel- und Tüchleinmalerei des Mittelalters», *ibid.*, pp. 125-259; *Giotto to Dürer. Early Renaissance painting in the National Gallery*, ed. by J. Dunkerton, S. Foister, D. Gordon & N. Penny, New Haven/London 1991, pp. 193-204. See also the literature quoted in n. 1-2.

²⁶ Alberti, 2002 (as in n. 15), p. 35.

the individual objects²⁷. Alberti, however, also acknowledges that some more capable artists may wish to follow their natural talents and work without relying too heavily on mathematical aids and principles²⁸. However, this relativization of strict rules was less urgent, when it came to creating smooth transitions by means of light and shade, for mathematically exact laws were problematical *a priori*. When talking about smooth transitions, Alberti recalled the *compositio* of antique rhetoric, for which hard and fast rules were similarly no longer relevant. To create a good composition, grammar, understood as a strict set of rules, was insufficient, as it could not guarantee the grace of transitions between the words and the individual parts of speech. These thoughts ultimately echo in Leonardo's late theories on light and shadow and in his practice as a painter²⁹.

The softening of outlines resulting from *sfumato* was a theme that Leonardo pursued with a marked intensity, perhaps independently of Alberti and antique rhetoric, in the first decade of the sixteenth century. During this period, he considered the measure of sight to be a relative affair, as air combines with rays of light to produce a general haziness in front of distant objects³⁰. At the same time, Leonardo's interest in the identification of different values of shadow was becoming an increasing part of a purely theoretical study of infinitely divisible movements and continuous (infinite) quantities³¹. The fact

²⁷ Quintilian, 1920 (as in n. 24), Book VII, chapter 5, 26-30, and Dionysus Halicarnasus, *De compositione verborum*, ed. and trans. by S. Usher, Vol. II, Cambridge/London 1974/1985, pp. 22-23 and 54-55; See also K. Patz, «Zum Begriff der *Historia* in Leon Battista Alberti's *De pictura*», in: *Zeitschrift für Kunstgeschichte*, 49, 1986, pp. 269-287, 276.

²⁸ Alberti, 2002 (as in n. 15), p. 32.

²⁹ Leonardo, *Libro di pittura*, 1995 chapters 45 (derived from *Libro A*, fol. 17), 412 and 413, all datable to ca. 1508-1510.

³⁰ *Ibid.*, chapters 486, 740-743, and Leonardo da Vinci, *I manoscritti dell'Institut de France*, ed. by A. Marinoni, Firenze, 1986-1990, 12 vols. (*Manoscritti A-M*) [hereafter: Leonardo, *Manuscript A-M*], vol. 4, *Manuscript D*, esp. fol. 9v-10v. Useful summaries of *Manuscript D* can be found in E. MacCurdy, *The notebooks of Leonardo da Vinci*, [London 1938], Reprint, Vol. I, London 1977, pp. 206-239; A.M. Brizio, *Scritti scelti di Leonardo da Vinci*, [Turin 1952], Reprint, Turin 1980, pp. 397-405, whose dating of the manuscript to ca. 1500-1506 seems to me more plausible than that proposed in M. Kemp, «Leonardo and the visual pyramid», in: *Journal of the Warburg and Courtauld Institutes*, 40, 1977, pp. 128-149. See also C. Pedretti, *Leonardo da Vinci on painting. A lost book (Libro A)*, Berkeley 1964, pp. 211-212.

³¹ Leonardo, *Libro di pittura*, 1995, chapters 721 and 810; Cf. M. Rzepinska, «Light and shadow in the late writings of Leonardo da Vinci», in: *Raccolta vinciana*, 19, 1962, pp. 259-266; Nagel, 1993 (as in n. 23); Pedretti, 1964 (as in n. 30), pp. 49 and 127 (the latter

that a certain paradigm shift had meanwhile taken place is also evidenced in Leonardo's late studies on optics and perspective. These studies led to the realization that, though a perspectival construction may be mathematically impeccable, the fact that it was tied to a single, fixed point meant that it was unable to recreate the conditions of perception encountered by the viewer³². It now seemed that scientific perspective, having served as the primary guarantor of painting's claim to rational legitimacy since the Quattrocento, contradicted the nature of sight dependent upon movement. No perspectival construction, however complex, could completely imitate natural binocular vision³³. It also emerged that the mathematically exact calculation of shadows projected in perspective was not an uncomplicated affair³⁴. Prior to 1500, general belief held that harmony was still possible between the rationality of geometric forms and optical laws on the one hand, and subjective perception on the other. However, this notion was profoundly undermined by recognizing the limited degree to which reality could be objectively measured and reproduced on the basis of rational laws. This finally led Leonardo to conclude, around 1505, that sciences such as arithmetic and geometry could, in fact, only provide information about the quantity, but not the quality of things. Quality is the beauty of nature, the adornment of this world and cannot be recognized without shadows³⁵. Shadows thus give objects a quality that goes beyond their scientifically measurable quantity.

Leonardo's eagerness to furnish his science of painting with rational rules did not evaporate altogether after 1500. In the years between 1505 and 1510,

is derived from Leonardo, *Manuscript M*, fol. 18, ca. 1500; and from Leonardo da Vinci, *Il Codice Atlantico della Biblioteca Ambrosiana di Milano*, ed. by A. Marinoni, Firenze, 1975-1980, fol. 199v-b.

³² Kemp, 1977 (as in n. 30); J. S. Ackermann, «Leonardo's eye», in: *Journal of the Warburg and Courtauld Institutes*, 41, 1978, pp. 108-46. More recent literature on this subject can be found in C. Farago, 1992 (as in n. 7), pp. 94-95.

³³ See Veltman, 1986 (as in n. 2), pp. 321-326.

³⁴ See Kaufmann, 1975 (as in n. 2), pp. 267-275.

³⁵ Leonardo, *Libro di pittura*, 1995 chapter 17 (after 1500); and Leonardo's note in the drawing *Windsor RL 19076r* which is datable to ca. 1513 (Richter, 1970 [as in n. 7] 121). The last remark is found on the corresponding sheet in the context of thoughts on light, shadow, colour and aerial perspective (see Richter, 1970 [as in n. 7] 59, 158, 195, 204, 209, 265, 287 and 292).

for example, he sought to measure progressively darker shades of color (quite literally by the spoonful), in order to extrapolate from the quantities of black pigment mathematical laws for *sfumato*³⁶. The correct proportion for the shades of color is achieved in a scientifically sound manner with the following device:

With whatever color you wish, take a little spoon, not much bigger than an ear spoon, but larger or smaller according to how large or small is the work on which the operation has to be carried out. The spoon should have an even rim and with it you will measure out the quantities of the color you will use in making your mixtures³⁷.

For Leonardo, it was important that painterly composition using *sfumato*, with its blurred and less precise effect, should remain measurable and thus satisfy the scientific standards he claimed for art. Just as he had insisted prior to 1500 that the perspectival construction should be governed by proportionality, so *sfumato* was now to obey a law of proportion by the spoonful. In comparison with the proportionality of perspective from twenty years earlier, this law was now couched in far less rigid terms.

After 1500, the suggestive evocation of pictorial space using aerial perspective—that is, the perspective of color and *sfumato*—became the standard for Leonardo and, within the next decade, for virtually the entire epoch. The emancipation from the rational construction of spatial depth extended all the way to the negation of pictorial space, as we are reminded by Leonardo's *St. John the Baptist* (fig. 7). The priority once given to the sharpness of outline and to a mathematically calculated perspectival construction gave way to a novel blurriness.

Even centuries later, this same shift of priority from sharpness to blurriness surfaces in the reception or the afterlife of Leonardo's work. The *Last Supper*, with its normative perspectivity and clearly drawn figures, remained the artist's most celebrated painting through to the nineteenth century, only to be ousted in the wake of Romanticism by the *Mona Lisa*. The portrait of Lisa del Giocondo, exhibiting neither an obvious perspective nor a clear outline, has since become the epitome of *sfumato* and auratic effect.

³⁶ Leonardo, *Libro di pittura*, 1995, chapters 433 and 756.

³⁷ Kemp/Walker, 1989 (as in n. 7), 552.

Perhaps it is precisely the bandwidth characterizing Leonardo's theoretical writings and his painterly oeuvre that has secured him the enduring attention of the wider public and the academic world. For some, the main attraction is the rational measure of sight, for others the measure of darkness, whereby both are showcased to perfection, on the one hand by the means of perspective, and on the other by the means of *sfumato*.

EPILOGUE

In 2011, a painting from a private collection entitled the *Salvator Mundi* was attributed to Leonardo da Vinci, which in older scholarship was considered to be a copy after Leonardo's original design³⁸. Although this painting shows all of the characteristics of Leonardo's late *sfumato*-style, it has been unanimously dated to around 1499. If both the attribution to Leonardo and the dating is correct, everything we have believed about Leonardo's *sfumato*, blurriness and the measure of darkness has to be reconsidered. If, on the other hand, our understanding of Leonardo's late *sfumato*-style is still correct, the *Salvator Mundi* has to be attributed to a close and very gifted follower of Leonardo who developed his *sfumato* to perfection.

³⁸ See especially *Leonardo da Vinci. Painter at the court of Milan*, exhibition catalogue, (London, National Gallery, 2011), ed. by L. Syson & L. Keith, London 2011. For a critical assessment of this attribution, see Zöllner, 2012 (as in n. 3), pp. 1-2.