Perspective.

Term used in two main senses with respect to art: generally, for any systematic technique that renders the illusion of recession behind a two-dimensional surface (including receding lines, gradients of colour, tone and texture, degrees of clarity etc); but also more specifically, for the geometrical technique of linear perspective, the modern form of which was invented in the early Renaissance.

I. Introduction.

The word perspective derives from the Latin perspectiva (It. prospettiva), which in the Middle Ages came to denote the whole science of optics, including the study of the eye, reflections and refractions. With the invention of linear perspective in the early 15th century, the scientific term was annexed by writers on art (see §II below). Existing literature on the subject has paid enormous attention to linear perspective, and full-scale historical reviews are available (e.g. Kemp, 1992), while other forms of perspective have been relatively neglected. This article gives more attention to the neglected topics, particularly the forms of depth illusion that use gradients of colour, acuity and chiaroscuro, methods collectively referred to as non-linear perspective. Although linear and non-linear perspective have often been used together in works of art, they are examined here separately in a historical context. Systems such as anamorphosis, which were developed as alternatives to basic linear perspective, are also examined separately.

The various perspectival techniques have proved continuously effective and robust in providing the artist with a means of constructing an illusion of space on a two-dimensional surface, but the precise status of perspective as an optically and perceptually accurate way of representing the world has been subject to sustained controversy. On the one hand, it is claimed that perspective (especially linear perspective) corresponds in a direct and non-arbitrary manner to the way in which visual stimuli are received and understood (Gombrich), while on the other it is argued that it is purely a convention characterizing a certain phase of Western representation, which has no claim to superior representational value (Francastel and Panofsky). It has also been claimed that linear perspective instituted a new way of seeing and that it was a major causative factor in the scientific revolution (Edgerton). This article, however, concentrates on a largely descriptive outline of perspective in the theory and practice of art, rather than the perceptual and philosophical controversies (for discussion of the perception of pictorial depth cues see PERCEPTION, §II).

Bibliography


P. Francastel: Peintre et société (Paris, 1956)
II. Linear.

At its simplest, linear perspective relies on the way in which sets of inclined lines tend to be read as signalling some degree of space behind the surface on which they are drawn.

1. Non-scientific.

Linear devices have featured in any phase of painting, drawing or relief sculpture in which a sustained attempt was made to evoke the appearance of forms in illusory space. Even the art forms of eras when the naturalistic representation of objects in space was not a primary goal (e.g. Byzantine painting) resorted to some form of rudimentary linear perspective to suggest the presence of, for example, a chair or building. There is considerable debate as to whether a form of scientific linear perspective was developed in ancient Greece, in particular if the concept of the ‘vanishing point’ (see §2(ii) below) was known. Evidence from surviving paintings (mainly vase decoration) is indecisive, and the historian has to rely largely on later reflections in Roman literary sources (e.g. Vitruvius’ treatise *On Architecture*) and paintings, especially those at Pompeii. Taken together, the evidence suggests that Greek artists developed systematic methods for the creation of space that bore a general resemblance to later geometrical perspective, and that the apparent convergence of parallel lines to a single focus was known, at least in the context of stage design (White). There is, however, no certain link between the artists’ techniques and Greek theories of geometrical optics (particularly Euclid’s *Optics*), and it is probably better to regard perspective in Classical antiquity as predominantly non-scientific in kind.

Non-scientific systems do not necessarily exploit the effect that parallel lines appear to converge towards a focus as they move away from us; rather they show lines as more or less retaining their parallel relationship or even as diverging in the distance (as ‘inverted perspective’). Just such a form of inverted perspective entered Italian 13th-century art (e.g. CIMABUE) via Byzantine painting. In the
later phases of medieval painting and in Netherlandish painting in the first half of the 15th century various systems were adopted that rely on the apparent convergence of parallel lines to broad zones of focus or towards axes (as in a herringbone pattern). The practice of Giotto established that lines below the viewer’s sight appear to slant upwards and those above to slant downwards, while those at a central (horizontal) level remain horizontal. He may have been responsible for establishing a technique by which selected sets of parallel lines (e.g. in the coffers of a ceiling) converge to a single point. By the time of Ambrogio and Pietro LORENZETTI in the 1340s, this rule of convergence and the intervals for horizontal lines had been clearly established for individual motifs within paintings but not for the overall space. There is no decisive reason to associate such techniques with medieval optical science, though it has been argued (Hills) that other aspects of the use of light by Italian 14th-century painters are related to optical texts by such philosophers as Roger Bacon and John Pecham.

In some forms of Asian art, especially Chinese and Japanese painting and drawing between the 12th and 17th centuries, non-geometrical forms of linear perspective were developed to high levels of sophistication (e.g. Du Jin: Enjoying Antiquities, hanging scroll, late 15th century; Taipei, N. Pal. Mus.; or Tosa Mitsunobu: Legends of the Founding of Kiyomizu Temple, handscroll, 1517; Tokyo, N. Mus.). Typically, one set of planes of rectangular or square objects are aligned parallel to the base of the picture, while the sides at right angles are shown at a relatively consistent inclination to denote the passage backwards from one zone of space to the next. Coupled with other depth cues, notably the strong use of texture gradients, atmospheric effects and the skilled foreshortening of individual forms (especially animals), a very distinctive form of layered yet apparently boundless space is created that is quite different from, but no less compelling than, the geometrically systematic space of Renaissance art. After the 17th century Western scientific models of linear perspective were increasingly adopted in Asian art.

2. Orthodox scientific.

(i) Invention and formulation.

The term ‘scientific perspective’ is in a sense anachronistic, in that scientia in the Middle Ages and Renaissance could refer to any body of systematic knowledge, but it does serve to differentiate the forms of perspective founded in optics and/or geometry from those that are more empirical. The invention of linear perspective in this ‘scientific’ sense is credited to the Florentine sculptor and architect Filippo Brunelleschi, probably before 1413 (Kemp, 1992). Unfortunately, Brunelleschi’s demonstration panels of the Baptistry and Palazzo Vecchio in Florence are known only through written descriptions by his biographer (probably Antonio Manetti), and we have no precise account of his methods. Brunelleschi may well have relied on the techniques of measuring real and apparent size employed in surveying, but it has also been suggested that he exploited, variously, medieval optical science, astronomical instruments, Ptolemy’s cartographic methods and the tracing of an image on a mirror.

The earliest text to codify linear perspective was Leon Battista Alberti’s treatise De pictura (1435–6; see ALBERTI, LEON BATTISTA). Alberti attempted to demonstrate the optical foundation of perspective in the visual pyramid, the vertex of which is in the eye. He describes a step-by-step procedure for the portrayal of parallel lines passing to the ‘centric point’ (later called the vanishing point) and how to determine the correct intervals for horizontal lines at progressively deeper positions in space (see fig.). On the basis of the resulting construction (a kind of tiled floor), any given form can be drawn in space in due proportion. Alberti’s formulation probably owed much to Donatello and Masaccio, who in the mid-1420s had developed Brunelleschi’s invention to serve the practical purposes of pictorial construction. In the relief St George and the Dragon (c. 1417; Florence, Bargello), Donatello had used a simple form of the convergence of parallel lines (as well as acuity perspective; see §III, 1 below). In the bronze relief Feast of Herod (c. 1423–7; Lille, Mus. B.-A.) on the font of the baptistery
of Siena Cathedral he created a tiled floor that observes the basic rules of linear perspective, while managing a good approximation to a consistent system in the remainder of the relief (see DONATELLO, §I; see fig.). Even more definitive was Masaccio's Trinity (c. 1425–7; Florence, S Maria Novella), in which the ribs of the coffered barrel vault converge assertively towards a vanishing point. Although there are some inconsistencies in Masaccio's construction, at least in part for pictorial effect, he was remarkably successful in locating God, Christ, the Virgin and St John in a box of illusionistic space, in front of which are the donors and a skeleton (a memento mori).

![Visual pyramid after Leon Battista Alberti: De pictura (1435–6), (i) side elevation: (a) picture plane; (b) equal divisions behind the picture plane joined to the viewer’s eye; (c) viewer’s eye; (d) points at which these lines cross the picture plane, which provide the horizontal divisions for (ii), a grid in perspective; (e) the ‘centric’ or ‘vanishing’ point](image)

The basic technique was rapidly adopted by leading artists from the 1430s onwards and used with particular effect for the construction of space in narrative paintings and in a new form of unified altarpiece. Particularly subtle use was made of perspective by Domenico Veneziano in his St Lucy altarpiece (c. 1445; Florence, Uffizi; see DOMENICO VENEZIANO AND FIG.), while PAOLO UCCELLO worked a series of obsessively complex and eccentric variations on the basic method. The sculptor Lorenzo Ghiberti, in the third of his Commentaries, compiled an anthology of medieval optical texts (mainly from Alhazen, Witelo, Bacon and Pecham) as a way of annexing optics for the theory of art but was unable to demonstrate that linear perspective was a logical outcome of earlier science. The greatest perspectivist of the mid-15th century was Piero della Francesca, whose book De prospectiva pingendi (Parma, Bib. Palatina, MS. Parm. 1576 [Italian]; Milan, Bib. Ambrosiana, Cod. Amb. C307 [Latin]) outlined two basic methods: one relying on the transfer of forms to a plane foreshortened in the manner of Alberti; the other using a step-by-step projection of key points from the plan and elevation of an object on to a plane. The precision of, for example, the Flagellation (mid-1450s; Urbino, Pal. Ducale; see PIERO DELLA FRANCESCA, §I AND FIG.) suggests that Piero put his theories into practice. A powerful use of perspective for illusion is found in the wall paintings of ANDREA MANTEGNA, particularly in the ceiling of the Camera degli Sposi (1465–74; Mantua, Pal. Ducale; see fig.), in which an open oculus gives the illusion of the sky and figures looking downwards.

Practical problems with linear perspective, especially when dealing with wide visual angles, had been apparent at an early date, but it was Leonardo da Vinci who first tackled the full range of geometrical and optical difficulties (Veltman; see also LEONARDO DA VINCI, §III). He undertook systematic investigations of optical changes occurring when the relative positions of object, picture plane and viewer are altered; contrived various devices for the automatic drawing of forms in perspective; looked at the functioning of the eye and the consequences of optical science for the theory and practice of painters' perspective; and experimented with unusual systems. The result of his varied inquiries was that he moved away from a straightforward faith in the kind of pictorial system outlined by Alberti and became more aware of the deceptions and complications of the visual process. He never abandoned linear perspective entirely as an effective method but did attempt to minimize its shortcomings while increasingly relying on other forms of perspective (see §II, 3 below).

In northern Europe, scientific linear perspective was first fully adopted in both theory and practice by Albrecht Dürer (see DÜRER, (1)). On his second visit to Italy in 1506, Dürer recorded that he was intending to visit Bologna to study with a master of perspective. His engraving of St Jerome in his Study (1514; see ) is one of the masterpieces of the use of perspective for compositional effect. He outlined his methods in his book Underweysung der Messung (Nuremberg, 1525). One of his techniques uses the full-scale method of projection in the Piero della Francesca manner, while his 'shorter way' more resembles Alberti (albeit with a minor constructional error). Dürer also played a crucial role in the development of optical-cum-mechanical devices ('perspectographs') for the drawing of forms in linear perspective, illustrating four perspective machines; few subsequent
treatises omit a discussion of such artificial aids, which range from a simple squared window to such highly automated machines as that invented by Lodovico Cigoli in the early 17th century (Kemp, 1992).

(ii) Later developments.

From the 16th century European artists were increasingly expected to have a command of basic perspective, and a series of treatises was published to meet the demand for instruction. The first printed treatise was De artificiali perspectiva by JEAN PÉLERIN (‘Viator’) in 1505. He was followed in France by Jean Cousin (see COUSIN, (1)), who played a vital role in disseminating the so-called ‘distance point’ method (see fig.). This method, of uncertain origin, relies on the convergence of the diagonals of a squared floor to a single point on the horizon line. (The distance between this point and the ‘vanishing’ point is equal to the distance of the viewer from the picture plane.) This method provided one of the two rules in Jacopo Vignola’s Le due regole della prospectiva pratica (Rome, 1583), with a commentary by the mathematician Ignazio Danti (see DANTI, (2)). The other method was essentially the projective technique of Piero and Dürer, and Vignola demonstrated the compatibility of the competing methods. The commentary by Danti is characteristic of the absorption of the painter’s techniques into the world of the mathematicians and scientists in the later 16th century. More or less elaborate demonstrations of the geometry of perspective were given by FEDERIGO COMMANDINI, Daniele Barbaro (see BARBARO, (1)) and GIOVANNI BATTISTA BENEDETTI. The mathematical treatments culminated in Guidobaldo del Monte’s Perspectivae libri sex in 1600 (see MONTE, DEL), in which the full rationale of the projective geometry of perspective was demonstrated at length. Above all del Monte showed how to determine the vanishing point for any given line and how to project any given shape on to a plane according to the relative positions of viewer, plane and object (see fig.).

In parallel to the adoption of perspective by mathematicians, there was a growing insistence in the new academies of art that the basic geometrical techniques should be learnt by the aspiring artist. Provision was made for the teaching of perspective in the Accademia del Disegno in Florence (founded 1563). Voices were raised during the 16th century, however, to the effect that such mathematical rules should not dominate artistic invention. A leading proponent of this view was Federico Zuccaro, who quoted Michelangelo’s support of his argument that judgement should supersede the pedantries in measurement.
In the 17th and 18th centuries competence in basic perspective was taken for granted by artists and patrons, and it continued to be of special importance in some branches of art, such as Dutch topographical painting (especially church interiors, such as those by Pieter Saenredam), and in illusionistic decoration of the kind that some Bolognese artists came to regard as their specialization. In the Netherlands a special form of ‘perspective box’ or perspectival peepshow was developed, of which the greatest surviving example is Samuel van Hoogstraten’s *Peepshow with Views of the Interior of a Dutch House* (c. 1657–61; London, N.G.). Treatises were published in growing numbers, particularly in France and the Netherlands, and many refinements and variations on the basic constructions were devised. The most important mathematically was in *Exemple de l’une des manières universelles*, a short tract issued by GÉRARD DESARGUES in 1636, which provided the basis for the teaching by ABRAHAM BOSSE at the French Académie Royale (see also §III, 3 below). Desargues, as recorded by Bosse, formulated one of the key theorems of projective geometry, the branch of geometry that deals with the unchanging features of figures when projected. However, Bosse’s dogmatic insistence on the rules met with considerable opposition. The dispute that saw him ejected from the Académie was a typical if unusually public example of the passions raised by perspective. Many illusionistic decorators applied the rules of perspective in a softened or compromised manner, but ANDREA POZZO in his practice (e.g. the ceiling decorations in S Ignazio, Rome) and in his beautifully illustrated two-volume treatise *Perspectiva pictorum et architectorum* (Rome, 1693–1700) advocated strict adherence to one vanishing point. Pozzo, like other perspectivists (most notably the Galli-Bibiena family), also used his skills in the service of stage design.

The most important theorists of linear perspective during the 18th century were Brook Taylor, an English disciple of Isaac Newton, and the German mathematician Johann Heinrich Lambert (see also §III, 4 below). Taylor’s rather austere treatises (*Linear Perspective*, 1715; and *New Principles of Linear Perspective*, 1719) were the subject of numerous commentaries, expansions and illustrated editions in Britain, most importantly by Joshua Kirby and THOMAS MALTON (*A Complete Treatise on Perspective in Theory and Practice on the True Principles of Brook Taylor*, London, 1779). Taylor’s influence was responsible for the ‘measure point’ method (see fig.) becoming the characteristic of British theory. The most remarkable artist to stand in this succession was Turner, who accepted the post of Professor of Perspective at the Royal Academy in 1807. Turner struggled valiantly if not always successfully to master the complexities of perspective, made telling criticisms of the shortcomings of the orthodox system and implemented it with considerable freedom in his actual paintings. Lambert’s *Die freye Perspektive* (Zurich, 1759) used a ‘perspective protractor’ to determine the vanishing points of any line so that any object could be depicted without use of its ground plan.

Generally speaking, overt and virtuoso use of perspective became increasingly less important during the later 18th century and the 19th, although the numbers of instructional books certainly did not diminish. The German topographical painters JOHANN ERDMANN HUMMEL and EDUARD GAERTNER were among those painters who continued to use perspective as a central feature of their style. During the earlier 19th century the large-scale, walk-in PANORAMA became a popular form of public
entertainment, following the lead of Robert Barker (1739–1806). One area in which perspective flourished was technical drawing, whether in the service of architecture or engineering, and various specialized systems were developed (see §II, 3 below).

Avant-garde artists of the 20th century mostly rejected orthodox perspective theory, and instruction in schools and academies became increasingly reserved for architects and other draughtsmen in technical fields. Artists such as Matisse used a juxtaposition of depth cues but not perspective as such, and the Cubists experimented particularly with multiple viewpoints (see CUBISM, §1; see also PERCEPTION). Those avant-garde artists who did continue to rely on perspective, for example Giorgio de Chirico and René Magritte, did not necessarily strive to be master technicians of perspectival construction; rather, they played with its power of illusion, often producing a sense of dislocation. With the questioning of modernism after the 1960s, there has, however, been a revival of interest in more traditional systems; this interest is reinforced by the perspectival base of computer-aided design. A few late 20th-century painters, such as Ben Johnson (b 1946) in England and Craig McPherson (b 1948) in America, developed techniques with an elaboration to match anything in previous perspectival design.

3. Anamorphic, curvilinear and orthographic.

The limitations of orthodox linear perspective, both within its own optical conventions and as a means of capturing visual experience, led to various attempts to formulate alternative systems, in some cases turning some of the peculiarities of the orthodox system to unexpected advantage. The extreme degradation of forms on the picture plane at very wide angles of view was exploited in an optical trick known as anamorphism. The image of a form on the picture plane is subject to extreme lateral stretching in such a way that if it is seen from the front it makes no coherent sense, while if it is viewed from a very shallow angle the image is rectified. Piero della Francesca was aware of the principle of anamorphism, but it was probably Leonardo who first exploited it fully. It became particularly popular in the 17th century and was used by François Niceron (La Perspective curieuse ou magie artificielle, Paris, 1638) and Emmanuel Maignan (Perspectiva horaria, sive de horographia gnomica, Rome, 1648) in the context of religious decorations, where it served as a form of miraculous revelation. Anamorphic images were also invented for conical and curved picture planes, and using a variety of curved mirrors.

The systems that were most regularly proposed as a complete alternative to the standard construction relied on various forms of curvilinear perspective. The basic reasoning is that wide or tall forms at right angles to our line of sight should undergo perspectival diminution towards their extreme edges. Thus a wide wall should appear to taper towards both left and right. This possibility was discussed by Leonardo, and a perspective device invented (1557) by Baldassare Lanci, which consists of a sighting arm rotating on a central axis, appears to have been designed to create a curved panorama for a 180° view. Although Carel Fabritius in his View of Delft (1652; London, N.G.; see FABRITIUS, (1)) appears to have precociously used curvilinear perspective in a panoramic view, fully fledged alternative systems do not appear to have gained much of a following before the 19th century, when Arthur Parsey advocated a variety of perspectives that exploit the upwards convergence of tall forms, while William Herdman in England and Guido Hauck in Germany devised methods that rely on curvilinear recession across the picture field. In the 20th century the most fervent advocates of curvilinear perspective have been Barre and Floccon (1968). The standard argument against curvilinear perspective (as marshalled by John Ruskin among others) is that the picture plane itself will be subject to lateral recession and the effect should not therefore be doubled. Another problem is that most curvilinear (and multi-dimensional) drawing systems achieve their effect by reference to the implied flat plane of the surface on which they are depicted, which functions as the traditional ‘window’ through which forms are viewed in perspective.

The most important alternative systems have been those developed for various kinds of technical drawing from which the user can extract precise information about relative or absolute dimensions.
Such systems were first developed for architectural representation, especially for schemes of fortification from the 16th century onwards. They rely on varieties of non-convergent (orthogonal or orthographic) perspective, in which the dimensions remain on a constant scale across more than one of three coordinates, because parallel lines are not shown as converging towards vanishing points. The most fully developed type is isometric, in which the relative height, depth and width of the forms remain constant throughout the depiction, allowing precise scale measurements to be taken. In dimetric, trimetric perspective etc, the ratios of measurements at right angles are scaled according to 2:1, 3:1 and so on. Isometric (dimetric etc) rendering has become a standard technique in engineering drawing and for some kinds of architectural draughtsmanship.

Bibliography

W. Farrish: *Isometrical Perspective* (Cambridge, 1820)

J. Joplin: *The Practice of Isometric Perspective* (London, 1833)

W. Herdman: *A Treatise on the Curvilinear Perspective of Nature* (London and Liverpool, 1853)

N. G. Poudra: *Histoire de la perspective ancienne et moderne* (Paris, 1864)

A. Lejeune: *Euclide et Ptolémée: Deux stades de l’optique géométrique grecque* (Leuven, 1948)


R. Easton: *Roger Bacon and his Search for a Universal Science* (Oxford, 1952)

E. Panofsky: *Early Netherlandish Painting* (New York, 1953)


J. Gage: ‘Ghiberti’s Third Commentary and its Background’, *Apollo*, xcv (1972), pp. 364–9

S. Edgerton jr: *The Renaissance Rediscovery of Linear Perspective* (New York, 1975)

J. Baltusaitis: *Anamorphic Art* (Cambridge, 1977)

M. Daly Davis: *Piero della Francesca’s Mathematical Treatises* (Ravenna, 1977)

A. Wheelock jr: *Perspective, Optics and Delft Artists around 1650* (London and New York, 1977)

E. Sjostrom: *Quadratura: Studies in Italian Ceiling Painting* (Stockholm, 1978)


M. Dalai Emiliani, ed.: *La prospettiva rinascimentale* (Florence, 1980)
III. Non-linear.

1. Definitions.

Non-linear perspective imitates the effect of distance on the colour, clarity and apparent relief of forms. Unlike scientific linear perspective, non-linear perspective has not been defined mathematically. On the other hand, like linear perspective, it is rooted in processes of vision and involves gradients of diminution and degradation. As J. J. Gibson (The Ecological Approach to Visual Perception, Boston, 1979) and other perceptual psychologists showed, gradients based on cues of depth perception, such as diminished acuity, can function as spatial devices in painting. Non-linear perspective encompasses several pictorial practices and a diverse theory. Historically, it has been known by various names, sometimes confusing and contradictory. Most often it is called aerial perspective after the French perspective aérienne, but it is sometimes known as atmospheric perspective. Aspects are known as tone perspective, colour perspective, shadow perspective, detail and clarity perspective. It can, however, be subdivided simply into three categories in order to establish a more precise use of terminology, namely colour, acuity and chiaroscuro.
Colour perspective refers to gradients of changes of hue, saturation, value and sheen of spectral colours. It is commonly seen in paintings where the colours of the landscape take on the blue of the sky, the white of the horizon or the golden or pink tint of the ambient illumination at sunrise and sunset. It also involves gradients from vivid colour to greyed colour or from darker to lighter colour and vice versa to depict various distances. Acuity perspective refers to gradients of distinctness, sharpness, clarity and detail. There are two types of visual acuity: that of distance, which is regulated by the accommodation of the eye muscles and the crystalline lens to adjust the focus for size and distance, and that across the visual field, owing to the sensitivity and spacing of visual receptors on the retina of the eye. Acuity perspective is accomplished in painting and sculpture (relief and free-standing) by reducing finish, eliminating detail, blurring edges of contours and interior forms, rounding angles and eliminating cues of texture. The perspective of CHIAROSCURO refers to gradients that diminish the illusion of three-dimensional form and the separation of figure from ground. It is accomplished in painting by reducing contrast between highlight and shadow values in modelling and in sculpture by shallower carving and low or flattened relief (rilievo schiacciato), which have the effect of reducing the contrast of natural light on the sculpture.

2. Origins, before the 16th century.

Non-linear perspective has been used in diverse pictorial traditions. For instance, the 11th-century Chinese landscape painter Xu Daoning's Fishing in a Mountain Stream (Kansas City, MO, Nelson–Atkins Mus. A.; for illustration see XU DAONING) demonstrates the Chinese study of atmospheric effects and diminution. The development of the practice outside Europe is, however, even less studied than its development in Western art. An early type of non-linear perspective in Western art appeared in 14th-century Italy, with the work of Giotto. In Flight into Egypt (see colour pl. VIII, fig.), the mountains behind the Holy Family are painted progressively darker to suggest greater distance. This practice built on Greek optical science, particularly the work of Ptolemy, who stated that vision gets weaker and objects more obscure with distance. It is also an extension of shading conventions derived from Classical antiquity in which light was used to indicate near parts and dark to indicate the far parts of objects (e.g., in painting, the Odyssey landscapes, Rome, Vatican, Bib. Apostolica; in relief sculpture, the Ara Pacis, 13 BC, Rome). Cennino Cennini recorded this practice of darkening mountains in Il libro dell'arte (written 1390s).

The most common type of colour perspective is a gradient in the colour of the sky from deep azure overhead to a light blue or white at the horizon. Erwin Panofsky identified the Book of Hours of Maréchal de Boucicaut (begun after 1401; Paris, Mus. Jacquemart-André, MS. 2) by the BOUCICAUT MASTER (see MANUSCRIPT, COLOUR PL. IV; see also MASTERS, ANONYMOUS, AND MONOGRAMMISTS, §1) as the first example of this practice in 15th-century Netherlandish manuscript painting. Shortly thereafter, panel painters such as Jan van Eyck and Rogier van der Weyden introduced colour perspective in the treatment of distant landscape, employing hue gradients progressing from browns and greens of foreground hillsides to azure mountains in the distance. Such Italian painters as Fra Angelico and Piero della Francesca also used colour perspective of landscape backgrounds, but with less vivid blues and less regularity. In the later 15th century several approaches to colour perspective co-existed, some employing a gradient from blue to white as in the Baptism (c. 1475–85; Florence, Uffizi) by Verrocchio and Leonardo da Vinci, some the earlier Netherlandish model and others a combination of the two, progressing first from diverse colours to blue and then from blue to white.

Fifteenth-century Italian sculptors also introduced acuity perspective, Donatello in rilievi schiacciati, such as St George Killing the Dragon (see also §II, 2(i) above), and Bernardo Rossellino in free-standing sculpture designed for one viewing point, such as the tabernacle (1449) at S Egidio, Florence, and the Annunciation (c. 1447–c. 1458; Empoli, Mus.). Perspective effects were created by reducing details, employing rounded and oblique edges to soften the appearance of contours,
eliminating undercutting to reduce the darkness of shadows and reducing polish to limit the intensity of light reflections.

3. Developments, 16th–17th centuries.

While the theoretical basis of these practices could be found in medieval visual science, it remained to Italian Renaissance artists and theorists to deduce artistic precepts from scientific principles. Leonardo da Vinci was inspired by medieval optics and meteorology in his early theory of colour perspective as well as his early writings on acuity perspective, which he called la prospettiva di spedizione or di notizia. His later writings show a greater awareness of Aristotelian ideas, and in general his extensive writings on non-linear perspective became the backbone of all subsequent theory.

The perspective of chiaroscuro also had its origins in Leonardo’s theory. In a passage in the Trattato della pittura (Rome, Vatican, Codex Urbinas, fol. 162) he defined the perspective of shadows as a fourth type of perspective. Examining the variables of distance and lighting in an attempt to identify the conditions for maximum relief, Leonardo observed the diminution of relief in the distance due to the lightening of shadows from reflections and the disappearance of highlights due to diminished acuity; the result was a reduction in ‘the quality and quantity of the principal lights and shadows’.

Raphael was a leader in putting the perspective of chiaroscuro into practice. A preliminary modello (Windsor Castle, Royal Lib.) for the left half of the Disputa (1508–11; Rome, Vatican, Stanza Segnatura) shows that Raphael varied the depth of shadow in accordance with distance. Not only did he apply a lighter wash on the heavenly figures at the top of the compositional arch (as Ames-Lewis observed), but he also used a lighter wash on the apostles at the left of the group, that is those intended to be in the conch of the semicircle, farthest from the spectator. In the absence of colour, Raphael experimented with tonal differences to create the effect of atmospheric distance, enhancing the diminution of size and reduction in clarity that already characterized his approach to spatial organization. Chiaroscuro perspective reached a level of mastery in the Expulsion of Heliodorus (1512–14; Rome, Vatican, Stanza d'Eliodoro), where Raphael placed the strongest lights and darkest shadows on the foreground figures and subsequently diminished the obscurity of the shadows and brightness of the lights in the middle ground and background figures and architecture.

Gradients involving the diminution of colour value (tone), coupled with a loss of detail and clarity, became popular in early 16th-century Florence, especially in indoor scenes such as Fra Bartolommeo’s second Mystic Marriage of St Catherine of Siena (1512; Florence, Accademia; see BARTOLOMMEO, FRA) and Rosso Fiorentino’s Marriage of the Virgin (1523; Florence, S Lorenzo, Archv Capitolare). Although Leonardo da Vinci criticized this practice in his Trattato della pittura, its renewal was inspired by his own practice of using a dark ground behind illuminated figures—to maximize relief—and by his use of sfumato, in which projections appear to emerge gradually from dark, obscured edges. Leonardo actually found support for the practice in the observation of nature and experimental science of light. Demonstrating a decrease in the illumination of objects with distance, and a tendency for shadows to become more dominant, he concluded that distant objects on the whole appear darker than those in nearer zones.

The theory of non-linear perspective was of little interest to 16th-century writers, with the exception of GIOVANNI PAOLO LOMAZZO. In his Trattato dell’arte de la pittura (1584), Lomazzo recommended a practice he called lume in perspettiva, in which the painter adds more light pigment in proportion to the distance from the viewer, to compensate for the colour degradation of normal viewing. He recommended it especially for paintings on vaults and praised both Titian and Polidoro da Caravaggio for using it perfectly. Lomazzo also opposed the practice of acuity perspective, despite his stated viewpoint that painters should imitate visual appearances. He praised the detailed finish of Dürer and Lucas van Leyden, arguing that acuity perspective is unnecessary since, as the quantity of air that affects our perception of the surface of the painting increases with viewing distance and as
the size of figures diminish, acuity will diminish naturally. Citing a lost perspective treatise by
Bernardo Zenale, he testified to the existence of debates on focus and finish in the early 16th
century.

Typical of 16th-century colour perspective, especially in northern Europe, was a schematic division
of the landscape space into three zones distinguished by abrupt colour changes (the ‘three-colour
scheme’). The foreground zone is usually brown or green, the middle ground a bluish green, and the
background a light azure, as for example in Joachim Patinir’s Assumption of the Virgin (see colour
pl. VIII, fig.). Sixteenth-century Italian practice tended towards an exaggeration of earlier
conventions, with a less schematic division of zones. Tintoretto, Veronese and others set up
decorative juxtapositions by exaggerating the shift from foreground colour and finish to background
lightness and unfinish, a practice that has been associated by Summers and Thornton with the
theory of contrapposto.

A desire for an ordered, more logical and more natural approach appeared at the end of the 16th
century. Northern painters, such as Adam Elsheimer and Abraham Bloemaert, introduced a more
gradual colour shift to the azure zone that commences closer to the foreground and also affects
figures and objects, producing an unnatural, ghostly appearance, as in Elsheimer’s Stoning of St
Stephen (see colour pl. VII, fig.). The Carracci family and other Bolognese landscape painters
initiated a natural, almost unnoticeable colour recession that leans towards a reduction in saturation
instead of a change in hue. Peter Paul Rubens made use of a shift from multicoloured foreground
to desaturated browns and greys in the background and peripheral figures. Later in the
century the azure became less pronounced as colour perspective imitated a variety of natural
lighting conditions, from the brownish and silvery greys of winter fog to the warm glow of summer
sunrise and sunset, as in the works of Jan van Goyen and Claude Lorrain.

Systematic theories of colour perspective were developed in the earlier 17th century with the
unpublished De colori, Prospettiva del colore, Prospettiva lineale and Della descrittione dell’ombre
prodotte da corpi opachi rettilinei (1618–22; Florence, Bib. Medicea-Laurenziana, MS. Ash. 1212) by
MATTEO ZACCOLINI and the second part of Abraham Bosse’s Manière universelle de M. Desargues,
‘Ensemble les places et proportions des fortes a foibles touches, teintes et couleurs’. Zaccolini
advocated the gradual introduction of blue at a different distance for each hue, depending on its
intrinsic darkness. He opposed an exaggerated practice of acuity perspective that leaves the
distance unfinished, but he regarded the perspective of chiaroscuro as an essential aspect of the
imitation of nature. He advocated a unified system in which the foreground figures are painted in
vivid hues with maximum chiaroscuro contrasts, to serve as a scale against which the systematic
diminution of colour and chiaroscuro can be compared. Bosse advocated a systematic degradation
and weakening of colour without giving specific guidelines on how to accomplish it. An illustrative
graving to the treatise shows progressively thinner, less dark lines creating chiaroscuro
perspective in graphic techniques. Such chiaroscuro perspective was widely practised by engravers
using a thinner burin to lighten the shadows of distant forms and spacing the lines more closely to
temper the illuminated areas in the distance.

Nicolas Poussin was inspired by Zaccolini’s treatises to develop a systematic approach to non-linear
perspective incorporating colour, acuity and chiaroscuro gradients. In SS Peter and John Healing the
Lame Man (see colour pl. VII, fig.) the colours are gradually desaturated without lightening in value
until the remote background and the number of tones used to model the drapery folds is gradually
reduced, and the contrast range of the chiaroscuro is gradually compressed until distant forms
appear flat and undefined. Poussin’s approach became the model for 17th-century French painting.
Claude Niçaise considered it evidence of Poussin’s superiority to Raphael, André Félibien criticized
Leon Battista Alberti for having ignored aerial perspective, and numerous others regarded aerial
perspective as evidence of the superiority of French painting to the Ancients and the Italian
Renaissance. Non-linear perspective was discussed in lectures and treatises on colouring and
perspective, including ‘official’ publications of the Académie Royale by Félibien and Henri Testelin.
The most popular and influential text was Charles-Alfonse Dufresnoy’s poem *De arte graphica*, translated into French and annotated by Roger de Piles (Paris, 1668; Eng. trans. by W. Mason, London, 1783). This advocated vivid colours and strong contrasts in the foreground, preceded by a dark foreground repoussoir, which would set up a scale from which the gradual lightening towards white would proceed. Two types of acuity perspective were recommended: gradients from finished foreground figures to less detailed backgrounds, and gradients from central focus to peripheral blur (analogized to a convex mirror). The publication of Leonardo da Vinci’s *Trattato della pittura* in 1651 was an equally important event for the history of non-linear perspective theory, for Leonardo soon became recognized as the primary authority on the subject.

4. Impact of modern colour science and visual theory, 18th–20th centuries.

In the 18th century Denis Diderot’s *Encyclopédie* treated non-linear perspective under the headings ‘Perspective aérienne’, ‘Coloris’ and ‘Chiaroscuro’, bringing together ideas on scale, gradients and atmosphere in addition to the standard concepts of the degradation of colour, light and shadow. Following de Piles, Diderot explained local colour in relation to perspective as the true colour of foreground objects before the effects of distance; and he reaffirmed the prevalent view that judgement and instinct, rather than specific scientific or mathematical rules, guided colouring and aerial perspective. While most writers continued to extol the virtues of ‘aerial perspective’, nevertheless protesting that it could not be subjected to scientific precision, those advocating the feasibility of scientific exactitude grew in strength and number with the advances in colour science that took place towards the end of the 18th century. Attitudes shifted from viewing colouring as ‘unteachable’ to establishing it as an authoritative part of the art curriculum. Baxandall (1985) showed that Pieter Camper’s *De visu* and other optical texts re-examined the issue of central–peripheral gradients of acuity in the light of modern Cartesian theories of vision and Lockean theories of perception; he argued that these ideas contributed to the acceptance of acuity perspective in such paintings as Chardin’s *Lady Taking Tea* (1735; U. Glasgow, Hunterian A.G.).

The most important contributions to the perspective of colour and chiaroscuro were made by Johann Heinrich Lambert, who had also written on linear perspective. Head of the physics section of the Berlin Academy of Science, he took up J. G. Sulzer’s challenge to make colouring as certain as linear perspective. He established a system for measuring even gradations of tones in 1768 and created a colour chart to relate hues to values in 1772, and in 1776 he determined a method for calculating the loss of local colour and admixture of white with distance. He launched the branch of physics known as photometry in *Photométrie sive de mensure et gradibus luminis, colorum et umbrae* (Augsburg, 1760) and showed in *Mémoire sur la partie photométrique de l’art du peintre* (Berlin, 1768) that photometry was equally valuable to the artistic practices of chiaroscuro modelling and the perspective of chiaroscuro, for he established a method of measuring reflectance (the percentage of light reflected on surfaces), which made it possible to calculate and reproduce the gradations of light intensity on the surfaces of objects. He established a scientific law of absorption for the decrease of the light passing through an absorbing medium of uniform transparency, which suggested the possibility of establishing precise guidelines for the degradation of colour passing through the air. However, the mathematical formula in his treatise on aerial perspective never won acceptance, owing to its inability to distinguish diminutions of colour value, saturation and acuity. Lambert’s own colour theory distinguished strength (saturation) from hue and value, but he was unable to devise a chart of equal, measurable saturation gradations that the painter could use as a guide to determine half, quarter and smaller fractions of colour strength.

In France, while such scientists as Pierre Bouguer, Gaspard Monge and Jean-Baptiste Biot advanced photometry and atmospheric optics, describing effects such as the gradations of light on convex and concave surfaces and the refraction of light through media of different densities, artists tended to work within the paradigm established by Leonardo, Dufresnoy and de Piles. On the other
hand, the more rational, systematic approach of Enlightenment science and many modern scientific concepts were wedded to these theories. M. de Saint-Morien distinguished the perspective of chiaroscuro from that of colour in his treatise *La Perspective aérienne* (Paris, 1788). He tested Leonardo’s theory that objects seen above a wall could look more or less distant depending on the colour and he also asked whether the same effect could be produced with hues of different value and saturation. Like Jean-Baptiste Oudry (*Réflexions sur la manière d’étudier la couleur*, 1749; *Discours sur la pratique de la peinture*, 1752), Saint-Morien opposed the principle of the dark repoussoir, criticizing Dufresnoy and de Piles and arguing for a two-phase system in outdoor scenes in which the maximum darks of the shadows would occur in the middle ground. The foreground of the painting would thus witness a gradual diminution of the intensity of the lights together with a gradual darkening of the shadows; after the point of maximum darkness the shadows would gradually lighten while the lights continued to undergo a diminution in brightness. He attributed the first effect to the drop-off in the quantity of reflected light reaching the eyes with distance; the second effect was ascribed to the humidity and ‘flexibility’ of the air that reflects sunlight to the eye.

The landscape painter *PIERRE-HENRI VALENCIENNES* included an extensive discussion of colour and chiaroscuro perspective in different atmospheric conditions in *Elémens de perspective pratique à l’usage des artistes* (Paris, 1799–1800/R 1973). He recommended that artists use perspective aids such as the camera obscura and the type of portable black mirror later known as the *CLAUDE GLASS*, which would reduce the varied colours of the landscape to monochrome value differences, making it easier to transform nature into gradients of colour and chiaroscuro. Lambert had also recommended the use of the camera obscura because it would reduce colour brightness in proportion, making it easier for the artist to match the lowered colours with paints. Such mechanical aids became superfluous with the invention of photography, which transformed the spectral colours of nature into shades of grey, making it easier for the painter to imitate value and acuity gradations in the distance without the need for theory.

In the course of the 19th century artists such as Turner, Constable, Courbet, Manet and Monet began to reject the tenets of traditional perspective theory as they attempted to capture the brilliance of natural light and colour using more vivid hues and fewer gradations of intensity and value. The invention of photography, coupled with a rising scepticism about the value of imitating nature, began to whittle away the assumptions underlying the scientific theory of non-linear perspective. Few modern perspective treatises discuss non-linear perspective, generally regarding it as an unsystematic imitation of nature requiring little instruction. A noteworthy exception is Len Doust (*A Manual on Simple Perspective*, London, 1935), who discussed the perspective of tone, detail and colour. His description of the ‘tone variation principle’ as the practice of placing more colour tones near the eye, and his application of tone perspective to the strengthening of foreground lines and intensification of foreground contrast in drawings, are worthwhile contributions, revealing the continuing value of non-linear perspective to modern artists interested in spatial effects.

**Bibliography**

*J. H. Lambert: Photométrie sive de mensure et gradibus luminis, colorum et umbrae* (Augsburg, 1760)  


*B. Teyssèdre: Roger de Piles et les débats sur le coloris au siècle de Louis XIV* (Paris, 1957)  


A. M. Schulz: The Sculpture of Bernardo Rossellino and his Workshop (Princeton, 1977)


T. Puttfarken: Roger de Piles’ Theory of Art (New Haven, 1985)


P. Hills: The Light of Early Italian Painting (New Haven, 1986)


M. Hall: Color and Meaning: Practice and Theory in Renaissance Painting (Cambridge, 1992)


J. Gage: Colour and Culture: Practice and Meaning from Antiquity to Abstraction (London, 1993)

J. Bell: ‘Aristotle as a Source for Leonardo’s Theory of Color Perspective after 1500’ (in preparation)

Janis Callen Bell