most constitution, human beings yearn to share in the fullness of God's love as it extends through space and time, beyond the natural social unit of generative family to society as a whole, and further still: beyond the earthly city to that 'heavenly Jerusalem' on the far horizon of Judeo-Christian thought.

And – to the extent that they respond – individuals, families, confraternities, religious communities, and the corporate family of the State can pass from division and death to a hard-won harmony: foretaste, in this life, of the life of God himself, Father, Son, and Spirit.

9 Masaccio and Perspective in Italy in the Fifteenth Century

J. V. Field

It has often been implied, and occasionally actually stated, that Masaccio was responsible for the introduction of perspective construction in art. This is true only in the very limited sense that Masaccio's works provide the earliest surviving evidence of the use of formal perspective in Renaissance paintings. That is, they provide pictorial evidence. There is convincing literary and documentary evidence that points very strongly to a perspective technique having been invented by Filippo Brunelleschi (1377–1446), in the sense that he devised some method of using a geometrical construction to obtain a convincing illusion of a third dimension in a flat picture. A document written in 1413 refers to Brunelleschi as "gran prospettico." This suggests that his invention dates from that year or shortly before. What Brunelleschi invented is apparently a real mathematical rule, that is, one that can be demonstrated to be mathematically correct. This interpretation of events is the most natural reading of what Antonio di Tuccio Manetti (1423–97) says about the matter in his biography of Brunelleschi.[1]

There is no good reason to doubt that Manetti is correct in presenting Brunelleschi as having invented a "rule" for perspective, but in interpreting the document of 1413, we need to bear in mind that the word we translate as "perspective," that is "perspectiva" or "prospectiva" in Latin ("perspettiva" or "prospettiva" in the vernacular), actually refers to the whole science of sight, which deals not only with the nature and properties of light but also with such matters as the functioning of the human eye. Describing Brunelleschi as "prospettico" thus meant he was considered an expert on what would now be called "optics." The term "optics," derived from Greek, began to replace the Latin *perspectiva* in the sixteenth century. This was not on account of the rediscovery of any important new Greek work on the subject. Greek optical work, largely that of Euclid (fl. c. 300 B.C.E.), formed the basis of *perspectiva* in the fifteenth and sixteenth centuries as it had in the thirteenth, when the

standard textbooks used in the fifteenth century had been written. As what we now call "perspective" came to be used in the visual arts, it acquired names such as "artificial perspective" *(perspectiva artificialis)* to distinguish it from *perspectiva* proper.

Brunelleschi would probably have called himself an engineer *(ingegniere)*, and he is now best remembered for his architectural activity, but he was trained as a goldsmith. There is no evidence that he ever practiced as a painter, except to paint two panels designed to demonstrate the effectiveness of his perspective technique. Moreover, there is no indication that painters felt any immediate need for the technique Brunelleschi had invented. Our first surviving evidence for its use is in the sculptured relief of *Saint George and the Dragon* by Donatello (1386–1466), in which the "picture," designed to decorate the base of Donatello's statue of the saint on Orsanmichele, Florence, is of course not quite flat, and, some years later, in paintings by Masaccio. Since interpreting the evidence provided by Donatello is somewhat difficult, Masaccio's work provides our most useful testimony in any attempt to understand what Brunelleschi may have invented. As evidence, Masaccio's work also has the recommendation of antedating the probably influential descriptions of perspective by Leon Battista Alberti (1404–72) in his treatise on painting, *De pictura* (1435), and its vernacular version, *Della Pittura* (1436), which was dedicated to Brunelleschi. The extent of Alberti's debt to Brunelleschi will be explored later in this chapter.

Brunelleschi's Invention

A good case has been made for supposing that a major reason for Brunelleschi's interest in optics and the apparent changes in size that natural optics introduces in what we see was his concern with proportions in architecture. He wanted to know how the proportions seen between various members would be affected when a building was viewed from different positions.[2] It is possible that this concern led him to make some drawings of building designs and to draw lines of sight on them in order to see the changes caused by a change of viewpoint. What we know of Brunelleschi's other work suggests he was good at mathematics – and we know apprentice goldsmiths were taught what was then a considerable amount of mathematics – so it may well be that making such drawings led him to notice some general mathematical rules. However, we do not know what they were. Nor is it overwhelmingly helpful that we know that the first of the two demonstration pieces he made was a picture of the Baptistery of Florence, and the second showed the Palazzo della Signoria (now called the Palazzo Vecchio) seen diagonally across the square in front of it. The choice of these subjects mainly tells us that his perspective technique worked well for buildings, particularly ones with a simple, regular shape. A glance at any

perspective picture will demonstrate that this is true of all perspective techniques. Even a superficial study of any book on perspective addressed to painters reveals the same story. Many such books were printed in the sixteenth century, and it is very probable that they preserve the rules followed in painters' workshops in the fifteenth century.[3] However, in analyzing a finished picture, from which construction lines will usually have been erased, it is important to recognize that it is only for simple objects containing a suitably large number of straight lines that one can actually check whether the representation is in correct perspective or not. The ideal and favorite object for perspective construction by artists, and for measurement by investigators, is the horizontal, tiled pavement. Such pavements are fairly common in fifteenth-century pictures. As Alberti makes clear in *De pictura*, the introduction of a pavement provides what is effectively a coordinate system for positioning objects in depth in the pictorial space.[4]

Many surviving works of art show Albertian pavements, which indicate that artists found them useful. It may be an indication of Brunelleschi's lack of engagement with painting that, from what we can learn of it, his technique does not seem to have been particularly well adapted to constructing such a pavement. For a start, the subjects of Brunelleschi's two demonstration panels suggest a method for constructing images of straight-edged shapes directly, rather than in relation to a ground plan laid out on a square grid. For instance, however the grid was laid out, the positions of some of the corners of the ground plan of the Baptistery could not be made to coincide with points easily defined in relation to a coordinate system. This is a consequence of a mathematical property of the regular octagon, and Brunelleschi's grasp of mathematics was assuredly good enough to understand it. Essentially, the difficulty is that while one can give a very simple geometrical construction for the regular octagon, it requires using a length that involves the square root of two, which cannot be expressed exactly in numerical terms. This means that one cannot give a simple arithmetical description of the positions of the corners of the octagon relative to a horizontal grid. It is possible that Brunelleschi's technique involved constructing the shape corner by corner, which would mean using sightings (real or simulated in a drawing) somewhat in the manner of a surveyor. However, this method would be tedious and does not really explain the choice of buildings that have a simple shape with straight edges that can be grouped into sets of parallel lines. It accordingly seems more likely that Brunelleschi's invention consisted in some relatively easy way of finding the images of sets of parallel lines.

We know now that if lines are parallel in the real three-dimensional scene, then their images in the perspective picture of it will be lines that meet at a point on the horizon, the horizon being defined as a horizontal line in the picture at the level corresponding to the height of the eye of the ideal observer. However, this result was first published by Guidobaldo del Monte (1545–1607) in 1600. We have no reason to suppose it was known to

artists in this general form in the fifteenth century.[5] However, a special case of this general theorem may have been well known. A rather casual reference in Alberti's *De pictura* (§19) suggests that it was well known that if the real scene contained a set of lines that were perpendicular to the picture plane ("orthogonals"), then the images of such lines in the perspective picture would be lines that converged to a "centric point" on the horizon (in the picture).[6] This convergence of the images of orthogonals may have been what Brunelleschi discovered and used as the basis for his construction technique. However, by the very nature of the optics and mathematics concerned, it is difficult to see how one might both discover and prove the theorem about the convergence of images of orthogonals without at the same time finding the more general theorem that is stated by Guidobaldo del Monte. In this case, what historians of science warily call "rational reconstruction" unhelpfully tends to lead us to something that seems to have been unknown. Several imprecise or untenable suggestions by art historians are better left uncited. I have suggested, somewhat speculatively, a possible derivation of the convergence of the images of orthogonals from the geometry of the planispheric astrolabe (an astronomical instrument well known to the learned of the time). This still seems to me to be more a mathematical possibility than a plausible historical explanation, but it does have the merit of being mathematically tenable.[7] However, in view of the mathematical traps inherent in this particular rational reconstruction, it is probably safer for the historian to fall back on the pictorial evidence.

Unfortunately, pictorial evidence on perspective needs to be handled with extreme care. Two cautionary examples will suffice. The first is the pair of pictures of chapels (c. 1305), shown in illusionistic style, on either side of the chancel arch in Giotto's fresco decoration of the Scrovegni Chapel, Padua (Plate 70). There is little doubt of Giotto's intention that these chapels should be read as "real" or of his skill in making them look so. Whether he did this by applying mathematical rules or merely by his customary skill in observation and draftsmanship is not known. The other example dates from some years later. An altarpiece by Ambrogio Lorenzetti, the *Presentation of Christ in the Temple* (signed and dated 1342; Florence, Galleria degli Uffizi), shows a fairly complicated tiled pavement that is in correct perspective if we assume the ideal observer is at a distance of about half the picture's width from the painting. This viewing distance is unrealistic, but similarly short ideal viewing distances are found in many fifteenth-century pictures, perhaps because if one uses the so-called distance-point method of construction, such a short viewing distance allows the construction to be carried out entirely within the picture field. However, we do not know whether Ambrogio used this construction, or indeed any construction that he knew to be mathematically correct. He may simply have been applying a construction rule that was known to work.[8] This seems to have been the attitude adopted by most fifteenth-century painters. On the whole, they seem to have used perspective constructions as simply

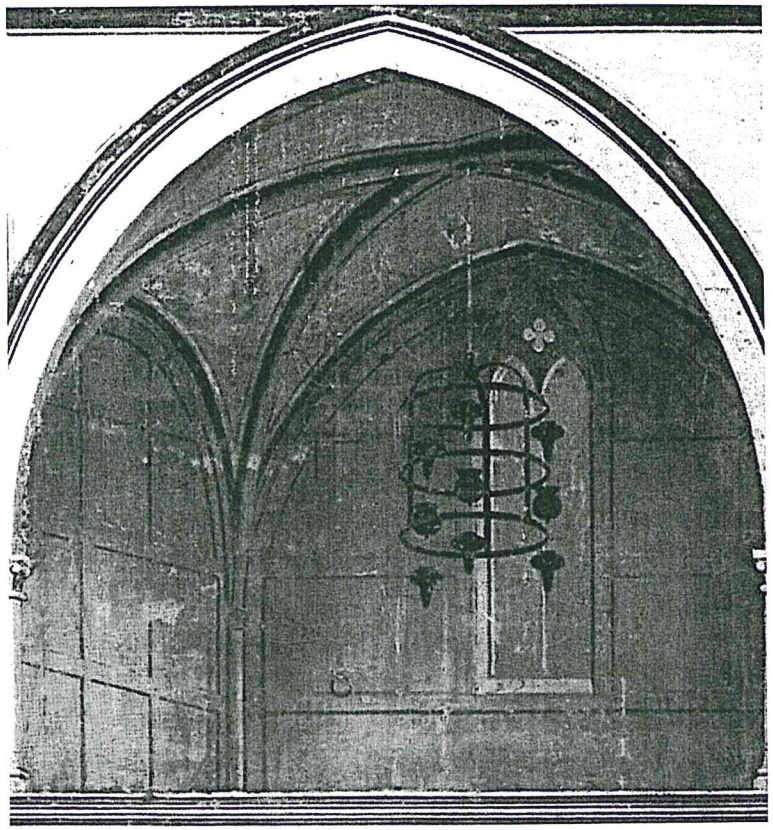

Plate 70. Giotto, *Illusionistic Niche*, 1305, Padua, Scrovegni Chapel. (Photo: Assessorato alla Cultura di Padova, Cappella degli Scrovegni, Padua)

one more tool in the making of pictures. The most obvious exceptions to this rule are Paolo Uccello (1397–1475), whose perspective constructions are often highly visible, Piero della Francesca (c. 1412–92), who wrote a treatise on perspective (see later discussion), and Andrea Mantegna (1431–1506), whose work belongs to a humanistic milieu, the ideas of which were expressed in, or maybe indebted to, the works of Alberti (both his writings and his construction projects).

Masaccio's Practice

Masaccio's case is simpler in the sense that in Florence in the 1420s, he was working in an environment where using perspective was not an established artistic fashion but an innovation. As a painter, he was thus out on his own, though there is good reason to suppose he turned to Brunelleschi for advice, and perhaps also to Donatello. Masaccio's work thus provides