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Article

Circling Round Vitruvius, Linear Perspective, and the Design of Roman Wall Painting

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Abstract: Many scholars believe that linear perspective existed in classical antiquity, but a fresh examination of two key texts in Vitruvius shows that 1.2.2 is about modularity and *symmetria*, while 7.Pr.11 describes shading (*skiagraphia*). Moreover, these new interpretations are firmly based on the classical understanding of optics and the history of painting (e.g., Pliny the Elder). A third text (Philostratus, *Imagines* 1.4.2) suggests that the design of Roman wall painting depends on concentric circles. Philostratus' system is then used to successfully make facsimiles of five walls, representing Styles II, III, and IV of Roman wall painting. Hence, linear perspective and its relatives, such as Panofsky's vanishing vertical axis, should not be imposed retrospectively where they never existed.

Keywords: linear perspective; *skenographia*; *skiagraphia*; Greek and Roman painting; Roman fresco; Vitruvius; Philostratus

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Two systems for designing Pompeian wall paintings have dominated modern scholarship: a one- or center-point perspective and a vanishing vertical axis.[1] Neither method works for all the variations seen on the walls of Styles II–IV. The vanishing vertical axis is considered a precursor of linear perspective, whereas center-point construction is a form of linear perspective. Many scholars believe that linear perspective was invented by the Greeks, only to be forgotten during the Middle Ages and "reinvented" in the Renaissance.[2] In contrast, I propose that linear perspective was not known in any form in antiquity but, rather, was an invention of the Renaissance, which also created its putative ancient pedigree.

1. Background

1.1. Definitions

First, it is important to define four key terms.

"Perspective" applies loosely to a wide range of systems that convert a three-dimensional scene to two dimensions. Most scholars, however, mean "linear perspective" when they use the unqualified term "perspective". No standard definition exists for linear perspective, but only linear perspective obeys the rules of projective geometry. Formal definitions refer to "station points" (the point or place for the "eye" of the "viewer" and/or "artist"), vanishing points, horizon lines, and picture planes, among other aspects. Horizontal lines converge to the "center point" or, in the case of

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1 This topic is remarkably complex with a massive bibliography. Small (2013) provides a reasonable summary of the scholarship to its date of publication. Since then, I have realized that the standard interpretations of key texts and objects needs to be totally rethought. This article, drawn from my book in progress, is the result. Unless otherwise noted, the translations are mine.

2 For example, for linear perspective in Antiquity: (Pollitt 1974, 2014; White 1987; Rouveret 1989, 2015; Senseney 2011; Stinson 2011; Stansbury-O'Donnell 2014; Smith 2015; Tanner 2016; Burnyeat 2017). For example, against linear perspective in Antiquity: (Lehmann 1953; Richter 1974; Pérez-Gómez and Pelletier 1997, pp. 97–111; Plantzos 2018).

"two-point" linear perspective, to two points, one on either end of a "horizon" line. Only "center-point" perspective is claimed for classical antiquity. Center-point perspective shares some characteristics with non-perspectival representations: (1) Foreshortening and diminution are not examples of linear perspective, but developed separately and independently. As Philip Thibodeau puts it, "linear perspective presupposes diminution, while diminution does not imply the use of linear perspective. Pompeian wall-paintings, for example, typically display consistent diminution, without showing anything like consistent central point perspective."[3] (2) Similarly, an oblique view of a building showing only the front and one side may look as if it were portrayed in linear perspective, but if the orthogonals do not converge, as in Chinese and Japanese art, then it is not linear perspective.[4] (3) Likewise, the presence of vanishing points is not exclusive to linear perspective. (4) Finally, most important of all and most diagnostic for identifying linear perspective is that linear perspective applies to the *whole* representation and determines how *all* elements are depicted. It should be noted that "*perspectiva*" is not a classical but a medieval word from the twelfth century, which referred to the "science of optics". In the sixteenth century, it became "perspective", as we use it today.[5]

"*Skenographia*", a Greek word, is generally translated as "perspective".[6] The Latin form, "*scaenographia*", appears in Vitruvius (1.2.2). Its two parts literally mean "painting (of) the stage", that is, the theater's façade (*scaenae frons*), or freely "scene painting". Aristotle (*Poetics* 1449a18), in its earliest extant citation, associates it with Sophocles and hence the theater. Its usage bifurcated during the Hellenistic period. On the one hand, its definition expanded to include "cityscapes" (e.g., Polybios 12.28a.6), which, in turn, later broadened to "painting" in general (e.g., Clement, *Stromata* 6.7.56). On the other hand, its use was restricted to a technical, architectural drawing or plan, as in Vitruvius (1.2.2) and Heron (*Definitions* 135.13.1–2).

"*Skiagraphia*", from its two components, means "shadow painting" or "shading". It also first occurred in the fifth century BCE. Over time "*skenographia*" and "*skiagraphia*" became synonymous (Hesychius, fifth-century CE lexicographer).[7]

Lastly, *vanishing vertical axis* (fishbone or herringbone) is the term that encapsulates Erwin Panofsky's theory about the design of Roman wall painting.[8] It refers to a central vertical "line" or axis in a painting with an unspecified number of points for the placing of diagonal lines that ideally define significant parts of a scene.

1.2. Brief History of Skenographia as Linear Perspective

The idea that linear perspective existed in classical antiquity goes back to the Renaissance and translations of Vitruvius' treatise on architecture into Italian.[9] Vitruvius in 1.2.2 lists three plans required for a building. The first two, a ground plan (*ichnographia*) and an elevation (*orthographia*), are straightforward, even if dressed up in Vitruvius' idiosyncratic use of Greek words.[10] The

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3 Thibodeau (2003, p. 146 n. 43), also with literary references. This is an excellent article on optical illusions.

4 Willats (2002, p. 412). Raynaud (2016, pp. 133–60), among many others, discusses alternative systems in Medieval art.

5 (OED (Oxford English Dictionary)), *s.v.* "perspective". For full discussion: (Raynaud 2016, pp. 1–12). For medieval usage: (Vescovini 2000).

6 LSJ 1608 and *BDAG* 1924–1925, both *s.v.* "σκηνογραφία" and related words (Liddell et al. 1968; Montanari 2015).

7 Hesychius, *s.v.* "σκιαγραφός". Intermediary steps led to the equation of the two words. For example, in the late fourth–early fifth century CE, Servius (*ad* Vergil, *Aeneid* 1.164) erroneously (from a modern point of view) claimed that "*scaena/skene*" came from "*skia*". On *skiagraphia*, among many, see (Rouveret 1989, pp. 13–63).

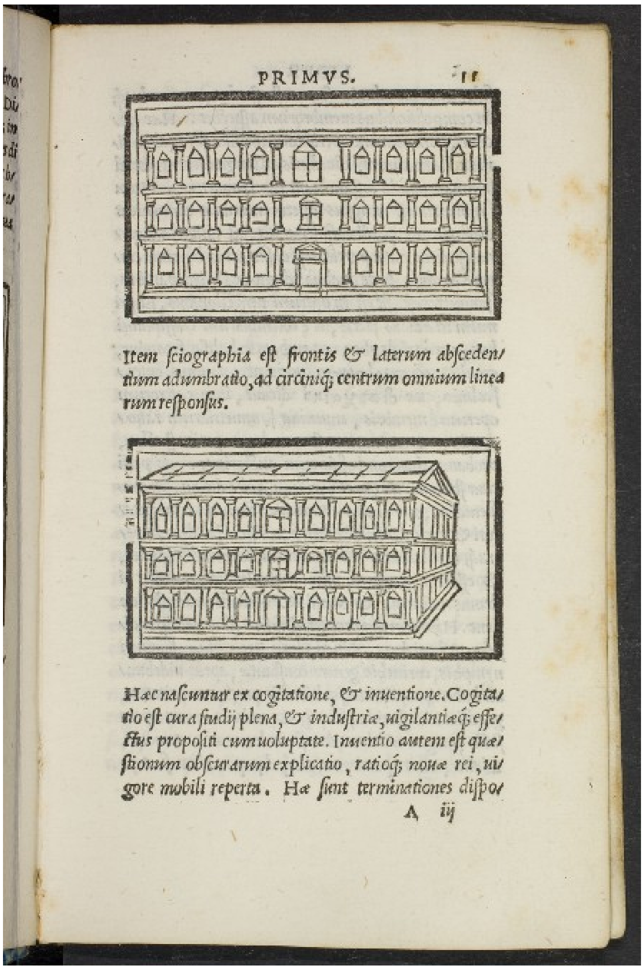
8 The idea of a vanishing vertical axis was first proposed by G. Joseph Kern, as Panofsky (1991, pp. 102–5 notes 20–22) acknowledges.

9 Vitruvius' treatise originally had no title. Its description as "ten books on architecture", often shortened to "on architecture", has evolved into a formal title today. See (Rowland and Howe 1999, p. 1). For background, see (Raynaud 2016), who cogently considers the evidence, especially Panofsky's (1991) idea of a vanishing vertical axis. Hart and Hicks (1998) provide a good introduction to early Renaissance printed books and include one of Rowland's (1998) many articles on Vitruvius. Also see Rowland's (2014) useful overview. For a detailed history of "perspective" in the scholarly literature, see (Hub 2008).

10 He is the sole classical source for *ichnographia*. *Orthographia* generally referred to "correctness of writing" and "orthography" rather than Vitruvius' literal interpretation of its two roots as "straight/upright drawing", on which *BDAG* (Montanari 2015),

sentence about the third plan, however, is one of the most contested passages in Vitruvius. Literally, it (Appendix A No. 1) says: "Likewise *scaenographia* is a drawing of the front and the receding sides and the correspondence (harmonious relationship) of all lines to the center point of the compass."[11]

Early Renaissance translators were not familiar with the word "*scaenographia*".[12] Undaunted, they substituted a word they knew, "*sciografia*" (Greek *skiagraphia*), a word not used by Vitruvius.[13] The change in vocabulary did not clarify what Vitruvius meant, but the illustrations for *sciografia* showed the façade and *one* side of a rectangular building in perspective (Figure 1). Claude Perrault in his French translation of 1684 (p. 10 n. 7) conclusively restored *skenographia*, while still translating it as "perspective".


PRIMVS. 11

Item sciographia est frontis & laterum abscedentium adumbratio, ad circiniq; centrum omnium linearum responsus.

Hæc nascuntur ex cogitatione, & inuentione. Cogitatio est cura studij plena, & industriæ, uigilantiæq; effectus propositi cum uoluptate. Inuentio autem est quæstionum obscurarum explicatio, ratioq; nouæ rei, uigore mobili reperta. Hæ sunt terminationes dispo

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Figure 1. Orthographia (top) and Sciographia (Bottom) from Fra' Giovanni Giocondo, *M. Vitruvii de architectu*, Third Edition (Florence, 1522) 11 recto.

s.v. ὀρθογραφία; and (Callebat and Fleury 1995, col. 72 [all three words], 359 and 368). This book is essential for anyone studying Vitruvius' vocabulary. The Vitruvius Budé (1969–2009) with excellent annotated volumes for every book in Vitruvius is indispensable.

11 Appendix A gives the original Greek and Latin for sources discussed in my text.

12 Early translations sometimes used "*scaenographia*", sometimes "*sciographia*" with various spellings. For example Fra Giocondo's 1511 edition used "*scenographia*", his 1522 edition changed it to "*sciographia*", but his 1523 edition returned to "*scenographia*". Di Teodoro (2002) analyzes the various changes undergone by Vitruvius' sentence with a helpful chart of who said what, when (p. 48). Virtually every early printed edition of Vitruvius can be downloaded for free. Two excellent websites are the following: Architetura (n.d.) and Vitruviana (n.d.). Vagnetti and Marcucci (1978) catalogued *all* 166 printed editions from 1486 until 1976.

13 Latin used two words, *lumen* and *umbra* (light and shade), for *skiagraphia*. See (Pollitt 1974, p. 252).

2. Literary Sources

2.1. Vitruvius 7. Preface. 11

Scholars cite one other passage from Vitruvius (7.Pr.11 = Appendix A No. 2) to support their claims of linear perspective. Vitruvius says that Agatharcus "built a *scaena* (stage building) and wrote a treatise about it". Two philosophers, Democritus and Anaxagoras

> learned from it [the treatise] and in turn wrote about the same subject [*res*]: that is in what way lines should respond in a natural relation [*ratio naturalis*] to the point [*acies*] of the eyes and the extension of the rays [*radii*] once a fixed [*certus*] place [*locus*] has been established as the center, in order that from a dimly perceived object precise images of buildings in the paintings of the stage-buildings [*imagines aedificiorum in scaenarum picturis*] [may] reproduce an appearance [*species*] with some [lines] seen extending [*prominentia*] and others receding when depicted on the vertical [*directus*] surfaces and fronts [of a stage-building/*scaena*].[14]

While the passage presents a number of problems, its reference to rays, a center point, projection, and recession are believed to describe linear perspective. The dates of Agatharcus and the two philosophers indicate the origin of *skenographia* in the fifth century BCE. That Vitruvius does not explicitly mention *skenographia* or connect this passage with 1.2.2 and vice versa is considered unimportant.

A comparison of 7.Pr.11 to other classical texts, describing projection and recession, however, confirms that it is not about linear perspective. Painters instead used color, shading, and shadows to achieve three-dimensionality. "Aristotle" (Appendix A No. 3), in one of the earliest citations on the topic, says: "Just as in a picture, if an artist represents two objects in colour, one as though it were at a distance and the other as though it were close at hand, the former object appears to us to be sunk into the background of the picture and the latter stands out in the foreground, even though both appear on the same surface."[15] "Alexander" of Aphrodisias (Appendix A No. 4), a second-century AD philosopher, in his commentary on Aristotle's *On the Soul*, explains the following:

> For the light does not fall in a similar way on all parts of what is uneven, because some of them are concave, some convex, some sideways on to the [source] of the illumination, some opposite to it. On account of these differences, even if what is seen is of a single colour, some [parts] of it seem dimmer, others more conspicuous, and thus some will be seen as recessed and others as projecting. Painters imitate this when they want to show on the same plane what is uneven, and make some parts light while shading others. Thus some [parts] of [what they paint] appear projecting, others recessed, and as projecting those that are made more light, as recessed those that are shaded.[16]

This description echoes that of 7.Pr.11 while unambiguously stating that color and shades produce projection and recession.

Next, "Alexander" (Appendix A No. 4) explains how the use of light and shading he just described fits within the system of optics:

> For it [sight] sees the things that it *sees by a cone which has the pupil as its vertex* and as its base the line which defines what [part] of the perceived body is seen and what not. . . . and the

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14 Burnyeat (2017) is the best article on the textual problems of the first half of this passage. His discussion of art historical matters adheres to the standard view of the linear perspectivists. Also see Rouveret's (1989, pp. 13–127) extensive discussion of both *skiagraphia* and *skenographia* B, to which she has returned in several articles. Recently see (Stansbury-O'Donnell 2014, pp. 155–60; Tanner 2016).

15 Translation adapted from Aristotle (1984, vol. 1, p. 1231). I changed the last clause, because, when we read "are really in the same plane", we automatically and anachronistically think of linear perspective, even though "plane" in and of itself need not refer to a "picture plane". In short, "plane" here is not the "picture plane", but the "[plane] surface of the object itself".

16 "Section A". Translation from (Sharples 2004, pp. 136, 139–40). All words in brackets are from Sharples' translation. Philoponus, in his commentary on Aristotle's *Meteorology* 374b14–15, is similar; see (Summers 2018, pp. 169–70).

> colouring, as it were, that comes about . . . *in straight lines in a similar way to light* . . . . It is by *the angles of these cones that [sight] judges larger and smaller and equal things*. For it sees [as] equal those things the sight of which involves equal angles, [as] larger than those which involve larger ones.[17]

First, whatever we see comes to or goes from the eyes in straight lines. Hence, straight lines and rays are not exclusive to linear perspective. Second, Democritus and Anaxagoras then, to their surprise, realized that shading and shadows made things look "real", in our terms three-dimensional, and notably did so not with curved rays, but the usual straight ones.

Alexander's passage raises another crucial point: "[Sight] sees and judges size by the angle of the cone which is formed towards the sight." According to Gérard Simon:

> [T]he perspective of the ancients (at least in its theoretical exposition) is 'angular' (or curvilinear), instead of being 'planar' as that of the Renaissance: in the perspective of the ancients, the apparent size of a receding object diminishes not as a function of its distance, but as a function of the angle under which it is seen—which does not amount to the same.[18]

My interpretation of projection and recession is confirmed in a number of other passages.[19] Porphyry (Appendix A No. 5), in his commentary on Ptolemy's *Harmonics*, uses painting as an analogy for how music works: "Thus just as in painting, when someone uses colours to make one thing resemble what is far away and another resemble what is nearby, one of them seems to us to recede from the painting and the other to stand forward, though both of them are on the same surface, so it is too with sounds and the voice."[20]

Before his full discussion of the history of painting, Pliny the Elder (Appendix A No. 6) summarizes the major advances in painting:

> At length the art [of painting] differentiated itself and invented light and shades, using a diversity of colors which enhanced one another through their interaction. Finally *splendor* was added, which is something quite different from light. That which exists between light and shade they called *tonos*, and the transition from one color to another they called *harmoge*.[21]

Pliny emphasizes the role of "light" (*lumen*) whether in contrast to "shade" (*umbra*) or "highlight", as "*splendor*" is commonly translated.[22] Completely absent is any mention of *skenographia*. Pliny's emphasis on color, along with light and shade, reflects the ancient assessment of painting. Philostratus (Appendix A No. 7), in the following century, also defines painting as "imitation by the use of colours . . . [it] reproduces light and shade."[23]

Artists and philosophers, such as Anaxagoras and Democritus in Vitruvius 7.Pr.11, were interested in the same phenomena—shading and shadows. Anaxagoras and Democritus were known for their investigations of vision, how colors change, and how eclipses work.[24] Thus, these two philosophers

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17 "Section B". For translation, see previous note.

18 (Simon 1987, p. 316; Simon 2003, pp. 17–42). Some scholars believe that Euclid's *Optics* (Definition 4 and Theorem 10) supports the existence of linear perspective in antiquity: (Smith 2015, pp. 47–72). Others, however, maintain that Euclid says nothing about linear perspective: (Andersen 1987, 2007, pp. 724–25). She provides very clear explanations of Euclid's theorems. Philip Thibodeau (2016) presents an excellent survey of classical optics.

19 On projection and recession, compare: Longinus, *On the Sublime* 17.3. Plutarch, *On the Malice of Herodotus* = *Moralia* 863 E; *Moralia*, Aratus Fragment 14; *Moralia* 57c "How to tell a flatterer". Lucian, *Zeuxis or Antiochus* 5.3–5.8. Porphyry, *Commentary on the Harmonica of Ptolemy*, 70 line 12. Philostratus, *Life of Apollonius*, 2.20.

20 Translation from (Barker 2015, p. 231).

21 Translation (and italics) from (Pollitt 1974, p. 399 No. 2). See his discussions (pp. 439–441 and 399–400) on "*splendor*" and "*lumen et umbra*".

22 On *splendor*, see (Gombrich 1976, pp. 1–18, especially p. 9). Rumpf (1947, p. 14) puts it well: "They [scholars] had only to ask a lady who powdered her nose what was the difference between *lumen* and *splendor*, between light and shine."

23 Translation from (*LCL* 1913, pp. 3, 5).

24 For Anaxagoras: Sextus Empiricus, *Against the Logicians* 1.90; Theophrastus, *On the senses*, 27. On eclipses, see (Kirk et al. 1983, pp. 380–82 No. 502 = DK 59A42 = Hippolytus Ref. 1.8.3–10; Beare 1906, pp. 37–40; Casati 2004,

had good reason for reading Agatharcus' treatise with its discussion of how shading and shadows produce an impression of projection and recession.

2.2. Lucretius, On the Nature of Things, 4.426–431

A passage in Lucretius' *De rerum natura* (Appendix A No. 8) has also been misinterpreted:

> When we gaze from one end down the whole length of a colonnade, though its structure is perfectly symmetrical and it is propped throughout on pillars of equal height, yet it contracts by slow degrees in a narrowing cone that draws roof to floor and left to right till it unites them in the imperceptible apex of the cone [*donec in obscurum coni conduxit acumen*].[25]

At first, Lucretius seems to refer to a vanishing point and therefore central projection. Euclid (*Optics*, Definition 2; Appendix A No. 9), however, uses similar wording that precludes the idea of a vanishing point: "and that the form of the space included within our vision is a cone, with its apex [κορυφήν] in the eye and its base at the limits of our vision."[26] If the top of the cone vanished, so would the image. Lucretius, instead, means that objects are not viewable from a distance. Lastly, classical depictions of colonnades do taper from the sides to the center but never come close to meeting, much less disappearing.

In conclusion, wishful thinking lies behind the interpretation of the three "core" classical texts as proof of linear perspective. Agnès Rouveret, for example, remarks that "their judgments [Roman writers on art and especially Pliny the Elder] magnified the 'invention' of light and shades, based on the fascinating power of color and not only on the perfect mastering of the line."[27] The idea that what Pliny says accurately reflects ancient painting has been passed over despite the numerous references to light, shading, and shadows in classical texts.

3. The Evidence from Classical Art

Scenes interpreted as using linear perspective, such as the abovementioned literary references, are few and problematic. Despite the purported origin of *skenographia* in the fifth century BCE, the earliest cited objects are fourth-century South Italian vases. The scene on an Apulian volute-krater with the death of Thersites epitomizes the problems.[28] In the aedicula, Phoenix and Achilles are shown head-on despite the fact that building's rafters are seen from below. The figures and objects around the aedicula are also depicted orthogonally in their own spaces with separate ground lines. Greek and Roman artists do not think in terms of whole scenes, but only the parts. Hence, classical artists often combined various "techniques" within one picture, such as hierarchical and semi-bird's eye perspective.[29] Linear perspective, however, imposes it rules on *all* elements of a representation, something rarely achieved in classical art.

No one disputes that Roman wall painting displays three-dimensionality, only how it was achieved. Shading and shadows do not need linear perspective to look so three-dimensional that crows see

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pp. 62, 72–73). For Democritus: (Kirk et al. 1983, pp. 428–29). Beare (1906, pp. 23–37) on shadows and colors. For an accessible scientific discussion of shadows, see Casati, *passim*.

25 Translation from (Latham 1951, p. 143).

26 Translation from (Burton 1945, p. 357). For the definition as "apex of a cone", see (Liddell et al. 1968, p. 983, s.v. κορυφή 4).

27 Rouveret (2015, p. 120).

28 Boston, Museum of Fine Arts 1900.03.804. https://collections.mfa.org/objects/154078/mixing-bowl-volute-krater?ctx=d78bcef0-adc8-46b5-8ebf-b004a0db5fd8&idx=4 (Plantzos 2018, p. 162 Figures 155–56). The Apulian fragment in Würzburg (Martin von Wagner Museum Inv. H 4696/4701)—the most frequently cited example—has similar problems (Plantzos 2018, p. 163 Figure 157).

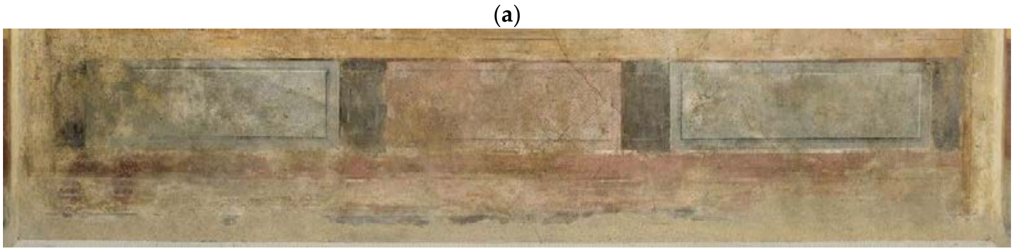
29 Small (2009).

real grapes.[30] Linear perspective alone, however, fools no birds.[31] Such effects are easy to achieve, as the dado in the cubiculum from Boscoreale shows (Figures 2 and 3).[32] The green rectangular panels appear to be set within a red frame, because the left vertical and lower horizontal parts of the frame are highlighted, whereas a darker or shadowy line defines the upper horizontal and right side. If the two sets of lines are reversed, placing the highlight on top, the panel projects, as on the dado on the back wall of the cubiculum.

(**a**) (**b**)

Figure 2. West (**a**) and end (**b**) walls of the cubiculum (Room M) from the Villa of P. Fannius Synistor at Boscoreale, ca. 50–40 B.C. New York, Metropolitan Museum of Art 03.14.13a–g. Source: Museum Photo—Open Access; *Creative Commons.*

(**a**)



(**b**)

Figure 3. Details of dados from Figure 2: inset panels on side walls (**a**) vs. projecting on the end wall (**b**). Source: see Figure 2.

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30 Zeuxis' grapes: Pliny, *Natural History*, 35.65. Other examples from accounts of Greek art include the following: horses neighing at Apelles' painted horse (ibid., 35.95) and cows mooing at Myron's cow, on which see (Squire 2010), with full references. Leonardo da Vinci recalls a dog recognizing a portrait of his master, for which see (Kemp 1989, p. 34). According to Gombrich (1973, p. 194), Goethe called it "sparrow aesthetics". Compare: (Kiewig-Vetters 2009). For an excellent survey of classical visual illusions, see (Thibodeau 2003). Modern research has established that animals, or at least pigeons, can be trained to impeccably distinguish between two painters (Picasso and Monet). Watanabe et al. (1995); Watanabe (2001); and Huber (n.d.)'s website: *Avian Visual Cognition*.

31 Compare Leonardo Da Vinci, who said that "The first intention of the painter is to make a flat surface display a body as if modelled and separated from this plane. . . . This accomplishment . . . arises from light and shade, or we may say *chiaroscuro*" (Kemp 1989, p. 15).

32 For color photographs: (Bergman et al. 2010, pp. 31–32 Figures 55–57). For the most extensive documentation, see (Barbet and Verbanck-Piérard 2013). For full set of color photographs: https://www.metmuseum.org/art/collection/search/247017.

According to the literary sources, the use of shading and shadows began in the fifth century BCE—the same era in which *skenographia* appeared. Plutarch (Appendix A No. 10) calls Apollodorus "the first man to discover the art of mixing colors and shading".[33] He was known as the "*skiagraphos*", a word related to the word substituted for *skenographia* in early translations of Vitruvius. Nothing of his work or any other Greek monumental painter cited in ancient sources has survived. Although vase painting was technically limited in showing gradations of colors, three methods suggested shading: (1) darker paint strokes over a lighter "wash";[34] (2) color added after a vase had been fired, though it often flaked off;[35] and (3) hatching—a series of lines, often following contours, closely spaced together. The last technique is well suited for vase painting and may have been invented by a vase painter. The earliest extant example appears on a shield on an Attic red-figure vase from the first quarter of the fifth century BCE (Figure 4).[36] Hatching occurred regularly in tomb paintings from Macedonia from the fourth century BCE on, as well as in Etruscan and Roman painting. It was also used to depict cast shadows.[37] Lastly, Pliny details each painter's contribution to the development of shading and shadows from the late fifth century and Apollodorus through the fourth century to Apelles and Pausias. It took over a century to understand how shading and shadows worked in art, and even then, the later Roman painters added their own contributions.[38]

Figure 4. Hatching on the Lapith's shield. Attic red-figure kylix by the Foundry painter. Munich, Antikensammlungen, 2640. Source: Wikimedia Commons.

Roman wall painting in Styles II–IV with architectural frames is considered the best evidence for linear perspective in classical antiquity. Yet, no wall, much less room, consistently portrays

[33] Translation from Plantzos (2018, p. 129), who uses "shading" rather than "chiaroscuro" as in the *LCL* Plutarch, *Moralia* 4.495. Plantzos (2018) has an excellent discussion about shading and shadows—a topic that he emphasizes throughout his study. The main discussion begins on 129ff.

[34] Only single examples are mentioned here. Note that the database, BAPD (Beazley Archive Pottery Database), provides photographs as well as an up-to-date bibliography for all vases in its database. Dionysos and Maenads, Attic red-figure neck-amphora, from Vulci, now Munich, Antikensammlungen, 8732 (2344). *BAPD* 201659.

[35] For examples of Attic white-ground vases, see, among others, (Plantzos 2018, pp. 124–31).

[36] Attic red-figure kylix by the Foundry painter. Munich, Antikensammlungen, 2640. Interior: Lapith fighting Centaur. Hatching is on the Lapith's shield. *BAPD* 204363.

[37] Telemachus and Penelope on an Attic red-figure skyphos by the Penelope Painter, ca. 440 BC. Chiusi, Museo Archeologico Nazionale, C 1831. *BAPD* 216789 (Plantzos 2018, pp. 148–49 Figures 145–46).

[38] Plantzos (2018, pp. 187–89) similarly comments on the gradual process.

linear perspective.[39] More telling perhaps is the absence of linear perspective in narrative scenes, both mythological and historical, as well as in scenes of genre. Some modern "reconstructions" of painted walls show the structures that the painters purportedly had in mind. For example, a Second Style wall from the House of the Cryptoporticus at Pompeii has been modified to demonstrate what it would look like if linear perspective had been used (Figure 5).[40] Parts of the building, such as the two outside colonnades, invade the viewer's space to such a disturbing degree that linear perspective, as an organizing principle for Roman wall painting, is unlikely.

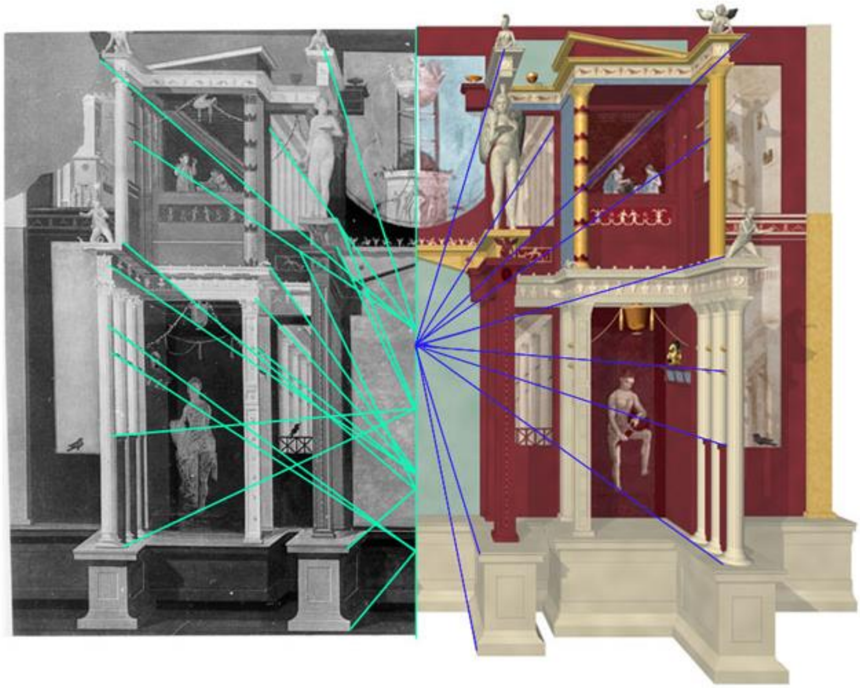

Figure 5. Frigidarium, House of the Cryptoporticus, Pompeii. Source: King's Visualisation Lab at King's College London, The Skenographia Project: http://www.kvl.cch.kcl.ac.uk/skeno01.html.

Finally, linear perspective is complex. It took approximately one hundred years in the Renaissance for artists to understand more or less how it worked. Classical painters spent a similar amount of time in refining their depictions of shading and shadows. Yet, classical scholars posit linear perspective springing whole, like Athena from Zeus' head, in the fifth century BCE with no antecedents.[41]

4. The Purpose of Vitruvius' *Skenographia*

The usefulness of ground plans and elevations for buildings is obvious, but the purpose of a *skenographia* has never been adequately explained. Before listing the three types of drawings, Vitruvius (Appendix A No. 11) discusses how they fit within the overall planning of a building:

> *Ordinatio* [order] is the ordinary [*modica*] aptness [*commoditas*] of the parts of the work separately and together, a comparison [*comparatio*] of proportion [*proportio*] to *symmetria*. This is based on size [*quantitas*], which is called *posotes* in Greek. Size [*quantitas*], moreover, is

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[39] The geometric decoration of Room 2 in the House of the Griffins in Rome may be an exception (Mazzoleni and Pappalardo 2004, pp. 67, 74–76). Richter (1974, p. 2) maintained that "A perspective drawing, therefore, can be produced merely by correct observation by an artist . . . without any knowledge of the laws underlying this phenomenon [linear perspective]."

[40] This reconstruction was produced by Martin Blazeby for the Skenographia Project (n.d.) of the King's Visualisation Lab. http://www.skenographia.cch.kcl.ac.uk/crypto/3dvis/3d02.html.

[41] For example, (Senseney 2011, p. 4) as part of the book's thesis.

> the taking [*sumptio*] of modules from the parts of the work itself and the harmonious result [*conveniens effectus*] [comes] from the individual sections of the parts.

First, a clarification must be made: English has only one word for "proportion", whereas Greek and Latin have two words—*analogia* and *symmetria* for Greek and *proportio* and *symmetria* for Latin. *Analogia* is more or less equivalent to our use of "proportion". *Symmetria*, however, did not mean "symmetry" in the modern sense of a mirror-image arrangement. It referred instead to the balance or commensurability among the individual parts of a whole. An extremely large head, for example, looks incongruous on a diminutive body. Thus, *analogia* refers to the relationships between whole things, while *symmetria* refers to the relationships within a single thing or whole. I use *symmetria* for the classical word and *symmetry* for our concept.[42]

Because Vitruvius repeatedly wrote about modularity, proportion, and *symmetria*, the absence of a drawing to guide their implementation would be surprising. Recall his definition of *skenographia* (Appendix A No. 1): "Likewise *scaenographia* is a drawing of the front and the receding sides and the correspondence [harmonious relationship] of all lines to the center point of the compass." Vitruvius explains what he means in 1.2.4 (Appendix A No. 12):

> Likewise *symmetria* is the consistent agreement among the elements of the work itself and the proportionate [*ratae partis*] correspondence [*responsus*] of the separate parts to the appearance of the whole form. As in the human body from cubit, foot, palm, finger, and the other small parts, the nature of *eurythmia* is *symmetros* (proportionate), so it is with the finishing of the work.

In Book 3 on temples, Vitruvius expands on 1.2.4. He uses a drawing of a man to show how proportion, based on a module, produces the "best" structures. He begins (3.1.1 = Appendix A No. 13) by rephrasing 1.2.2:

> The composition of a temple is based on **symmetry**, whose principles architects should take the greatest care to master. **Symmetry** derives from **proportion**, which is called *analogia* in Greek. **Proportion** is the mutual calibration of each element of the work and of the whole, from which the proportional system is achieved. No temple can have any compositional scheme without symmetry and proportion, unless, as it were, it has an exact system of correspondence to the likeness of a well-formed human being.[43]

Hence, Vitruvius recommends using modules rather than precise measurements, because modules are far easier to work with. Only the size of the module, not the individual measurements, has to be altered for resizing. All structures, no matter their size, using the same plan or model have the same number of modules, because modules do not have a fixed measurement until implemented. A modular system also circumvents problems arising from the absence of standardized measurements in classical antiquity.[44]

The similarities between a *skenographia* of a building and the Vitruvian Man (3.1.2-4), as the drawing is now called, are striking (Figure 6). Both are placed within a compass-drawn circle with a center point. Significantly both texts use a form of "*respondeo*" to describe how the parts "correspond" to the whole.[45] Vitruvius (3.1.9 = Appendix A No. 14) concludes the following:

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42 Despite frequent use of bilateral symmetry, Greek and Latin had no specific word to label the phenomenon. Bek (1993, p. 148 n. 10) credits Luca Pacioli (1447–1517) as the first to use *symmetria* in our sense of "symmetry". For a history of *symmetria*/symmetry, see (Hon and Goldstein 2008).

43 Translation and bolding of words from (Rowland and Howe 1999, p. 47).

44 Philon of Byzantium, last third of the third century BC, gives explicit directions on using modules for scaling. He thought that taking exact measurements of each part was "exceedingly awkward, slow, and not too accurate." From the *Belopoeica*, 55–56; translation from (Marsden 1971, pp. 115, 117) and commentary on (162–63 nn. 39–40).

45 "*Respondeo*" in various forms occurs in 3.1.3, 4, and 9.

> Therefore: if it is agreed that the numerical system was derived from human members, and that there should be a commensurable relationship [*commensus fieri responsum*] based on accepted units between those members taken separately and the form of the body as a whole, it remains for us to demonstrate the greatest respect for those who, when building temples for the immortal gods, arranged the elements of the buildings in such a way that, thanks to the proportions and *symmetriae* [*proportionibus et symmetriis*], the arrangement of the individual elements and whole corresponded to each other.[46]

Now, the most troublesome section of Vitruvius' definition of *skenographia* becomes clear. Vitruvius really does mean "all lines" are to "correspond" to the "center point", because he is not talking about linear perspective but *symmetria*. His qualification of "sides" with "receding" describes how they look.

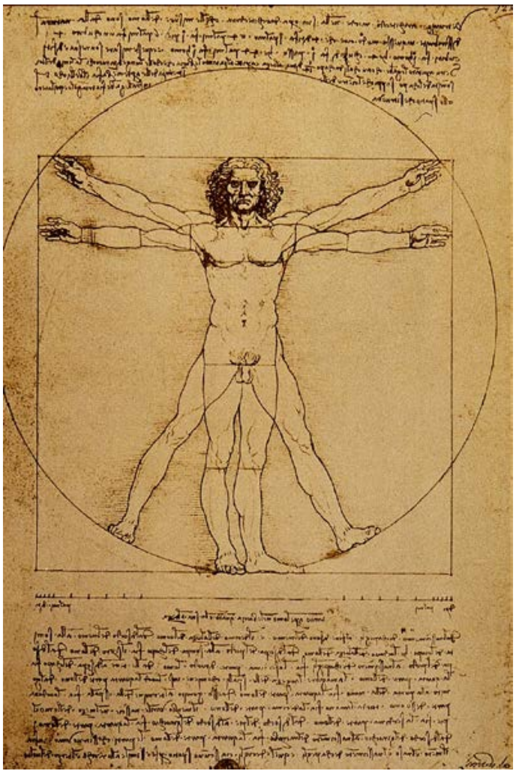

Figure 6. Vitruvian Man. Leonardo da Vinci. Source: Wikimedia Commons.

Only Cesare Cesariano, an independent and cantankerous translator (he included in his 1521 edition of Vitruvius a full-page illustration depicting an allegory of his wretched life), followed Vitruvius' directions (Figure 7).[47] Cesariano used the Duomo in Milan as his example. While the two sides show recession with diagonal lines, as Vitruvius prescribes, overall, the Duomo looks flat (Figure 8. Similar flat depictions of buildings with a single side and the façade occur in Roman representations. For example, the reverse of a bronze sestertius shows one side and the front of the shrine of Janus Geminus, see Figure 9).[48] Alberti (*On the Art of Building*, 2.1) also recommends a plain, flat drawing with no shading. James Ackerman explains that "The major Renaissance theorists opposed the use of perspective as a means of architectural representation because the receding lines would be unmeasurable

46 Translation from (Schofield 2009, p. 69). I have substituted *symmetria* from the Latin for Schofield's "modularity".

47 On Cesariano in general: (Rowland 1998, pp. 111–21). For one of the best analyses of Caesarino's *skenographia*, see (Hui 1993).

48 Also see: http://numismatics.org/ocre/id/ric.1(2).ner.512. A relief from the "Ara Pietatis", ca. AD 43, similarly depicts the Temple of Magna Mater (Kleiner 1992, p. 143 Figure 119).

and therefore misleading."[49] Furthermore, the three plans are not "presentation" drawings for a client, because what few ancient references we have indicate rough sketches not formal views. For example, Aulus Gellius (19.10.2–4) mentions plans on "*membranulis*", little pieces of parchment. Vitruvius, instead, prescribes the three kinds of drawings a builder needs.

In conclusion, neither of the two Vitruvian passages cited as evidence for linear perspective is about linear perspective. Vitruvius requires a *skenographia* for two reasons: to set the module for the construction of the entire building and to show how the parts of the building relate to each other and the building as a whole. The second passage, 7.Pr.11, likewise, is not about linear perspective, but shading and shadows, which first occurred in art in the fifth century BCE. The question, then, is what system did the Romans use to design their wall paintings?

Figure 7. Cesare Cesariano, Allegory of His Life. From Cesare Cesariano, *Di Lucio Vitruvio Pollione de architectura* . . . (Como, 1521) Book 6, folio LXXXXII verso.

[49] Ackerman (2000, p. 16). Isometric and axonometric drawings solve the problem of representing structures as three-dimensional while retaining accurate measurements. Both were introduced in the nineteenth century (Willats 1997, pp. 55–59).

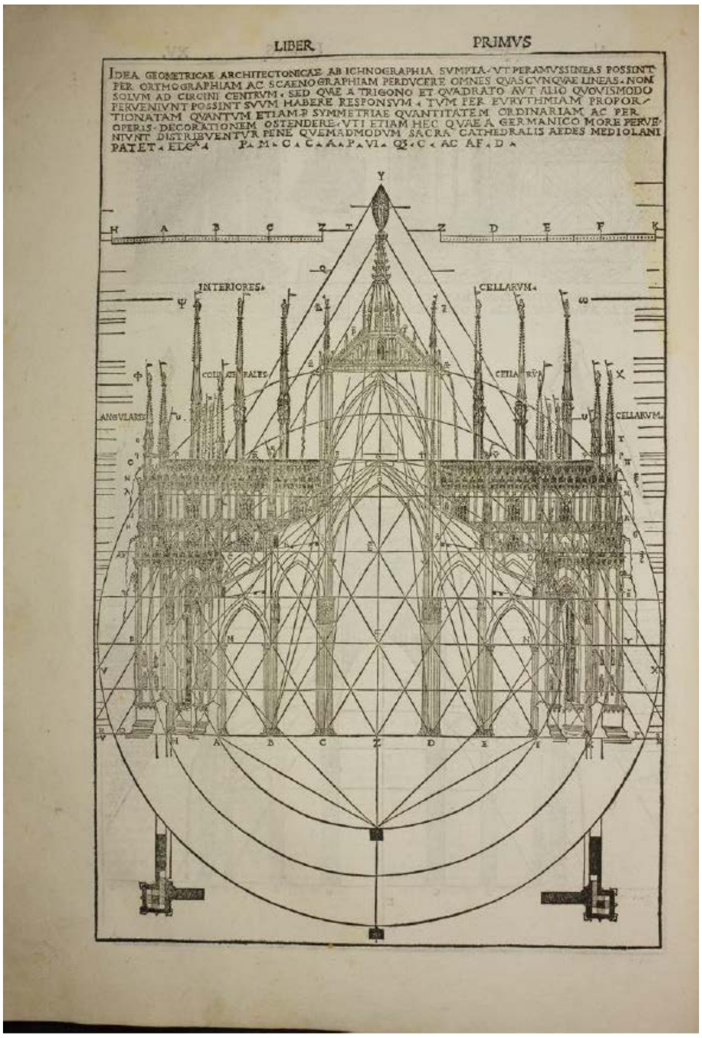

Figure 8. Cesare Cesariano, *Scaenographia* of the Duomo, Milan. From Cesare Cesariano, *Di Lucio Vitruvio Pollione de architectura* . . . (Como, 1521) Book 1, folio XV verso.

Figure 9. Nero on obverse; shrine of Janus Geminus on reverse of a bronze sestertius. Source: Wikimedia Commons.

5. Designing Roman Wall Paintings

5.1. The Evidence from Philostratus

Vitruvius depends on two simple tools, the compass and straight edge, for his plans of virtually all structures, whether for a house, temple, theater, or even the layout of a city.[50] Like the *skenographia* and Vitruvian Man, these plans all begin with a circle. Therefore, it is reasonable that the painted "architectural" Roman walls also used circles for their design. Textual support comes from Philostratus (Appendix A No. 15) in his description of a painting of the *Seven against Thebes*:

> The clever artifice of the painter is delightful. Encompassing the walls with armed men, he depicts them so that some are seen in full figure, others with the legs hidden, others from the waist up, then only the busts of some, heads only, helmets only, and finally just spear-points. This, my boy, is *perspective*; since the problem is to deceive the eyes as they travel back along with the proper receding *planes* of the picture.[51]

The last sentence refers to "perspective" and "planes", as is common in modern translations—a very free interpretation of the Greek.[52] Literally, however, the sentence says: "These are proportions [*analogia*], oh child. For it is necessary that the eyes be deceived, going back along the usual circles [*kykloi*]." *Analogia*, as I discussed above, concerns "size" in the sense of enlargement and diminution, based on a module, a circle in this case. Hence, Philostratus says that recession or depth was achieved not with linear perspective, but by using proportionate concentric circles. This method differs from the recession produced by shading and shadows. First, the concentric circles apply to the whole scene. Second, individual elements within a scene may also show shading.

5.2. The Circle Method of Design

Using concentric circles as the organizing principle, I have replicated whole Roman painted walls from scratch, no matter how complex, in each of the Pompeian Styles II–IV.[53] The system needs only five tools: a straightedge, cord and a peg or nail to anchor the cord for drawing circles, charcoal or chalk to make the guidelines, and sinopia for laying out the design.[54] I used *PowerPoint* to test the theory, because I already owned it, knew the program well, and could annotate each step on the slides. Moreover, its ubiquity means that scholars can easily test my results and even try their own experiments. These advantages were countered by *PowerPoint*'s inability to render small details accurately. So, I simplified repetitive sections such as colonnades by reducing the number of columns. Small bits and pieces are sometimes slightly out of whack. Nonetheless, the facsimiles are sufficiently accurate and recognizable to demonstrate that the system works for all three styles. I chose the walls frequently discussed by scholars as exemplars of linear perspective and their respective styles. Each style has at least one facsimile. Second Style walls, most often the focus of discussions, have three examples. Here, I give a brief description of how the system works using the cubiculum from Boscoreale in the Metropolitan Museum of Art, New York, as the example (Figure 2a [full wall] and Figure 10). Please see Supplementary Materials S1 for the other facsimiles, including a detailed analysis of the columns in the room from Oplontis (slides 5–10).

The wall is divided into four, not three or five, sections (Figure 2a). Since a pilaster separates the end section from the other three, I "recreated" only those three sections.

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50 On the importance of the compass and its role in Vitruvius, see (Saliou 2009, pp. 222–33).
51 Translation from *LCL*; my italics. I especially thank Susan Woodford for bringing this passage to my attention.
52 On the word "perspective" or *perspectiva*, see Section 1.1 *Definitions* above.
53 I am particularly grateful to Harrison Eiteljorg, II for suggesting that I try the system.
54 *Sinopia* refers both to the color, a reddish-brown, and to the "guidelines painted on the penultimate layer of plaster" (Clarke 1991, p. 4).

Figure 10. West wall from the cubiculum from Boscoreale, now in the Metropolitan Museum of Art, New York, 03.14.13a–g (Rogers Fund, 1903). Source: Metropolitan Museum of Art (Public Domain).

I began with a rectangle, the equivalent of a blank wall, on which I marked the center by dropping two diagonals from the top corners to the bottom corners (Figure 11).

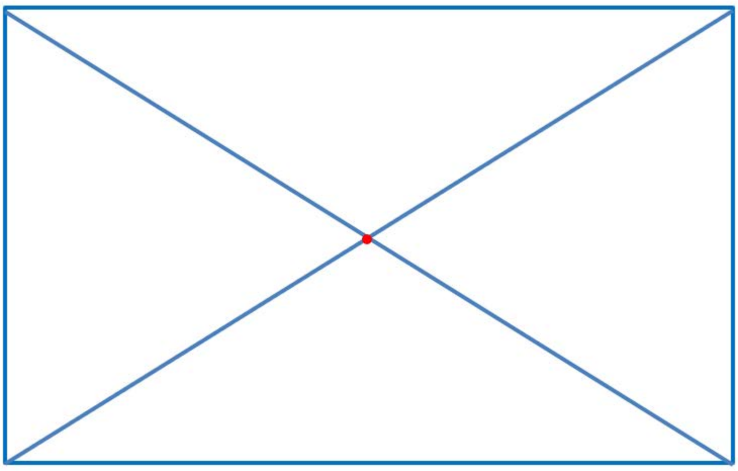

Figure 11. Finding and marking the center. Source: the author.

I then divided the space vertically and horizontally into four equal, symmetrical parts, analogous to laying out the *cardo* (vertical line for north/south) and *decumanus* (horizontal line for east/west) of a city (Figure 12). Alberti remarks, "We then relate all the measurements to those two lines. This works wonderfully in every way: the parallel lines are easily drawn, the angles can be defined accurately, and the parts conform and correspond exactly to one another."[55]

[55] Alberti, *On the Art of Building* 3.2. Translation from (Rykwert et al. 1988, pp. 62–63).

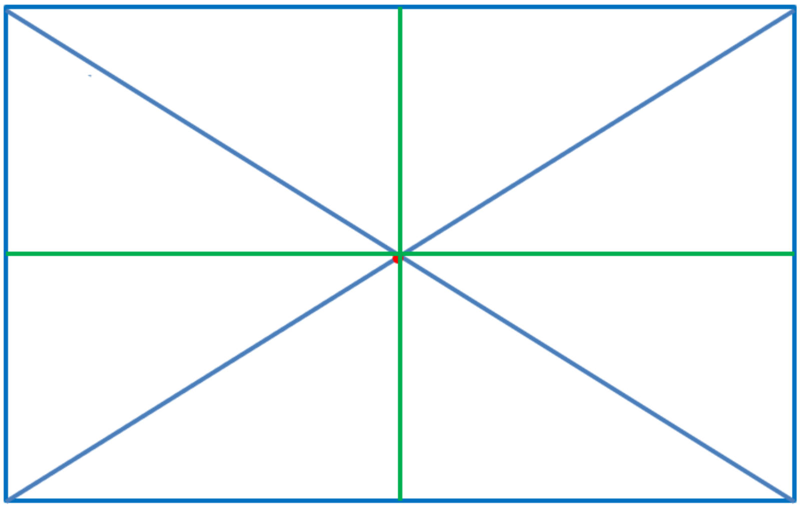

Figure 12. Dividing the wall into four quadrants. Source: the author.

Next, I removed the two diagonal lines for finding the center, because they were no longer necessary. Then, I added a set of concentric circles, using the center of the wall as their center point (Figure 13). The number of circles depends on the complexity of the wall: the more complex the more circles. My circles extend beyond the confines of the wall, because incomplete circles and arcs are difficult to make in *PowerPoint* (see Supplementary Materials S1). The Roman designer would have drawn only the arcs; that is, the circles would be left open on top and bottom.

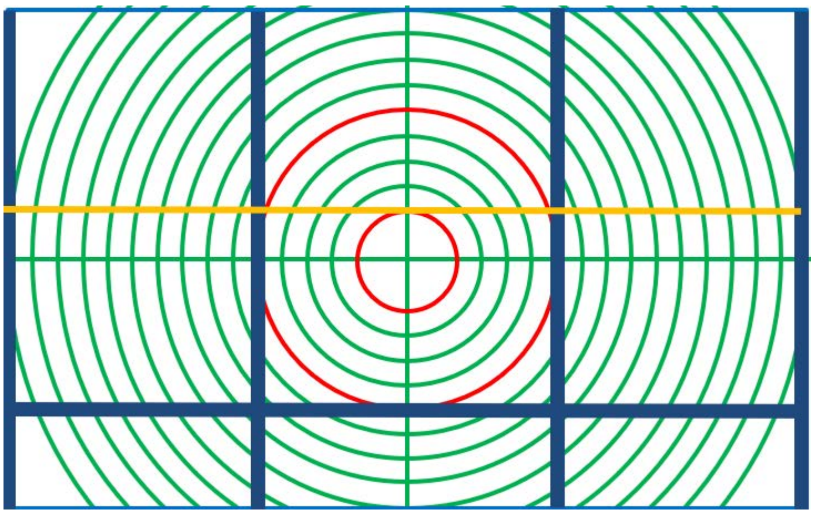

Figure 13. Diagonals removed, circles added, tripartite vertical division, and the dado. Source: the author.

Because painted architecture, unlike a real building, does not have to obey the laws of physics, I usually placed lines by eye to match the models. So, I next placed the major divisions of the wall: the three vertical sections with the center wider and the two horizontal divisions of the dado and frieze area. Because there is not a significant crowning moulding, I did not mark it. To make the process easier to understand, I have highlighted the circles here and in the following steps that define where each part is placed. The fifth circle from the center (colored red) determined the width of the center panel and hence the placement of the two vertical dividers (dark blue heavy lines; also at left and right edges). I next placed an orange horizontal line a little above the green horizontal line for the top of the "front" row of structures. Once the major divisions were set, I could work on any section in any order. The circles work like a grid for placing parts, which I discuss below. Because the designs are all bilaterally symmetrical, the painter has to design only half of the wall, as in the preliminary sketch from Oplontis, and then flip it element by element to the other half of the wall.[56] I followed the same procedure. In the case of the cubiculum from Boscoreale, the designer needed to plan only one vertical section, because both long walls are virtual twins.

Next, I worked on the central panel and its niche in orange (Figure 14). Four circles guided me. The inmost red circle (No. 1) defined the width of the niche. The outermost red circle (No. 6) determined the top of the "arch" over Hekate. Note how the inside lines of its two "pillars" likewise define the inside of the red niche "below" it. Hence, one vertical line suffices for both structures. To make the indentation of the niche, I used circles No. 4 and No. 5: No. 5 marked the bottom of the niche and No. 4 the recession. The two diagonal lines were placed by eye.

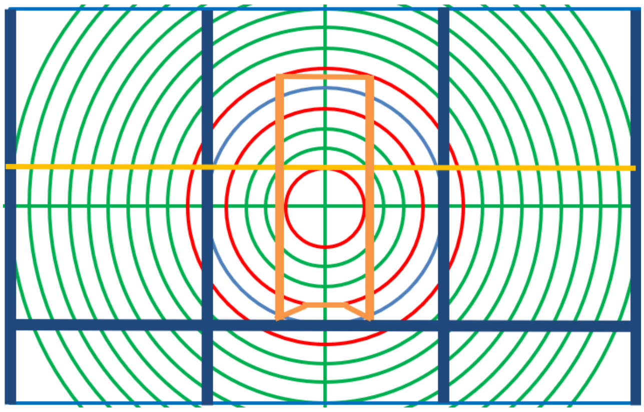

Figure 14. Placement of "structures" begins with center panel. Source: the author.

I then added the basic structures in orange in the lower portion (Figure 15). The two outer red circles defined the placement of the tall left and right structures, while the purple circles aided in the placement of the of the sections with doors. You do not have to locate the pertinent circles by counting from the center (or outside in). Just follow the appropriate circle from the left to the right side for accurate placement. Note how the purple circles define both the building and the recession for the side walls. At this point, it became clear that the flanking panels should have been a bit wider to more accurately reflect the doors in the actual frieze. Because I was studying the feasibility of using circles for the design, I did not think it was necessary to make any changes.

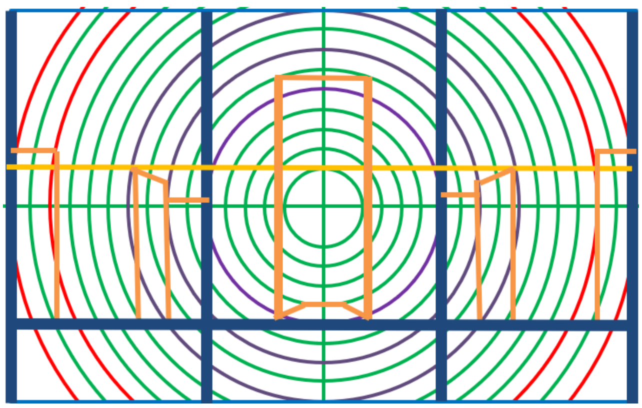

Figure 15. Lower structures added. Source: the author.

[56] From Oplontis, Atrium 5. Naples, Museo Archeologico Inv. 155730 (Bragantini and Sampaolo 2009, p. 106 No. 5). Clarke (2013) rightly notes that it is not a *sinopia*, but a sketch for the wall design of another room, Triclinium 14.

Next, I blocked out the tops of the buildings in the upper section (Figure 16). The pediment of the yellow structure on the outside of each panel is an example of the problem of exactly aligning small elements in *PowerPoint*.

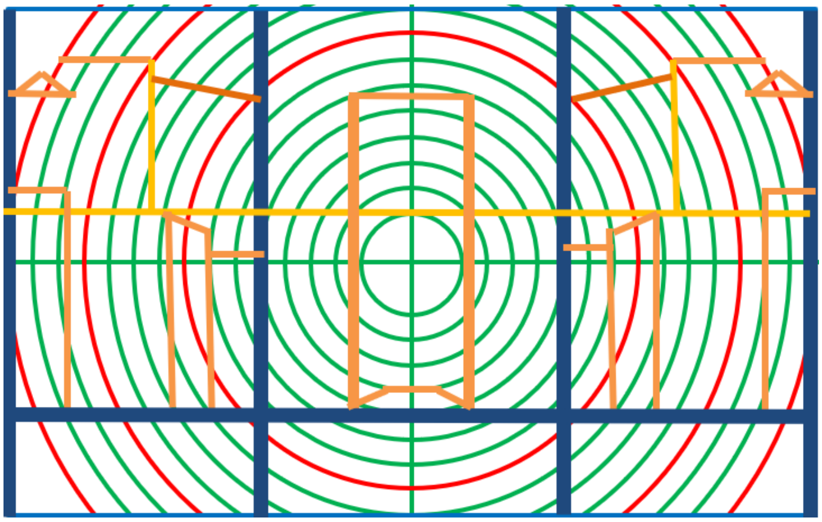

Figure 16. Upper structures added. Source: the author.

Details were added throughout the frieze: the loggias and divisions for various buildings in the upper portion, the windows and doors in the lower part, and the central niche and recessed panels in the dado. The dado area was reduced to allow for the green area in front of the lower buildings (Figure 17).

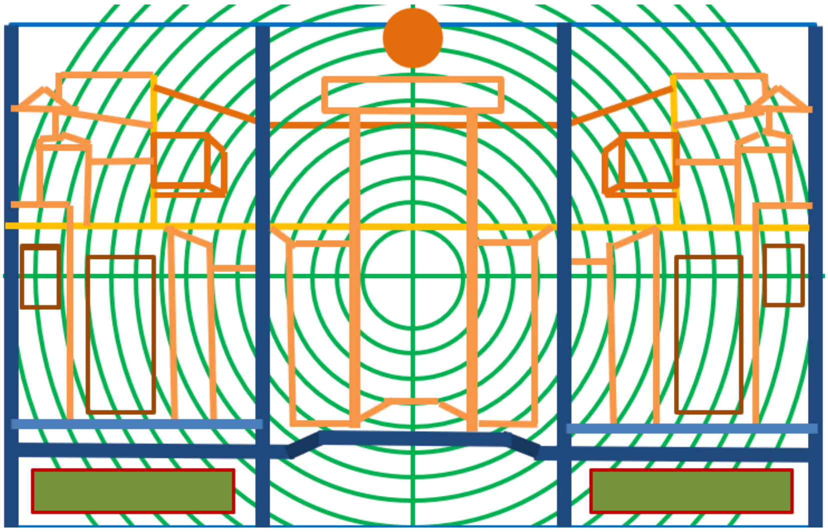

Figure 17. Final details added throughout. Source: the author.

All guidelines were removed and final adjustments were made (Figure 18). For example, the dark blue vertical dividers were "brought to the front" to cover the ends of the pale blue horizontal lines.

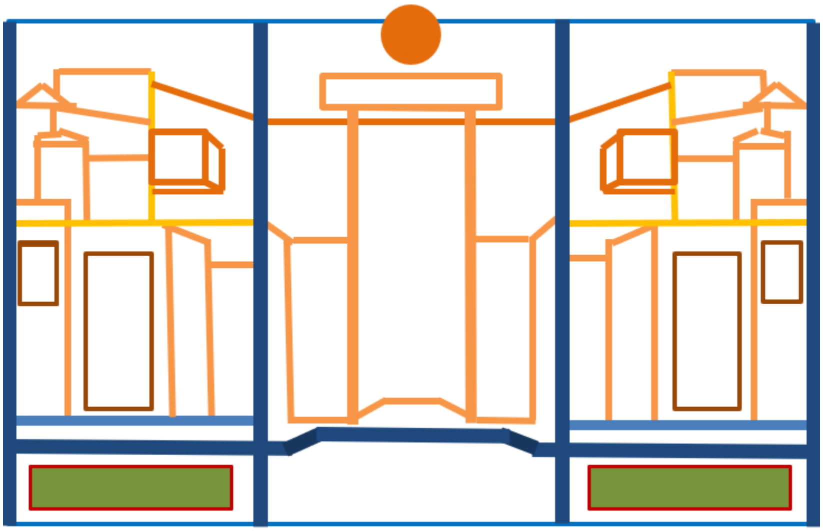

Figure 18. Guidelines removed, etc. Source: the author.

From my experiment I learned a number of things:

1. At no time did I need or use exact measurements. In *PowerPoint*, I copied each line segment on one side and then pasted it on the other side. In practice, a painter would mark a line segment from one side on a straight edge (or use a compass/calipers to measure the length) and place it in its equivalent circle on the other side of the central vertical divider.
2. Because the system is modular, as Vitruvius recommends, copying a motif or design from one building to another, such as the wall from the cubiculum of Boscoreale and its twin in the House of the Labyrinth, is relatively simple.[57] Scholars assume that grids were used to make the copies, but concentric circles also work well.
3. I automated the process by reusing the same rectangles and circles for different walls. I did not test whether the Romans also did so.
4. The system worked for all walls, no matter the style, no matter the shape (the narrow wall from the House of the Vettii vs. the other walls).

5.3. Variations as Before, I Use the Cubiculum from Boscoreale as My Example

5.3.1. Using Squares Instead of Circles

I converted the circles to nested squares (Figure 19). The squares, similar to the circles, enable one to maintain bilateral symmetry. On the one hand, squares are easier to work with in that their verticals and horizontals can sometimes be directly incorporated as elements of the scene. Note the central panel with the squares defining the vertical elements. On the other hand, it is easier to use a central peg and inscribe arcs with a piece of charcoal at the end of a cord than to measure the squares and align them exactly. Less significant, perhaps, is the absence of textual support. Although Vitruvius does place Vitruvian man in a square as well as a circle, he prefers circles as the base, as mentioned above (Figure 6).[58]

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[57] Clarke (2009) discusses the issue with regard to the central panels with figural scenes. He notes (p. 135) an example where a mosaicist used the exact same pattern on a 1:1 scale in two different houses. The four paintings he discusses here, however, vary in size, and Clarke suggests (p. 145) that scaling was done via grids.

[58] "Just as the figure of a circle can be traced out on the human body, so too the figure of a square can be elicited from it." "non minus quemadmodum schema rotundationis incorpore efficitur, item quadrata designatio in eo invenietur." Vitruvius 3.1.3. Translation from (Schofield 2009, p. 67). It is unclear from the Latin whether Vitruvius meant that "man" should be drawn in both a circle and a square as Leonardo did or separately in each. See (Gros 1990, p. 60).

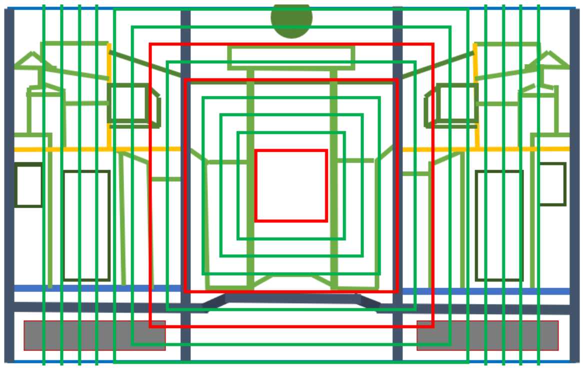

Figure 19. Nested squares instead of circles. Source: the author.

5.3.2. Grids

The circles can be used either independently or in conjunction with grids. If the two are used together, then more points for placing elements are available (Figure 20).

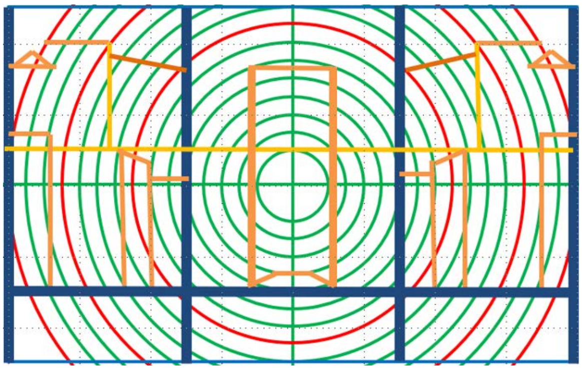

Figure 20. Grids and circles together. Source: the author.

As is well known, grids alone also work (Figure 21).

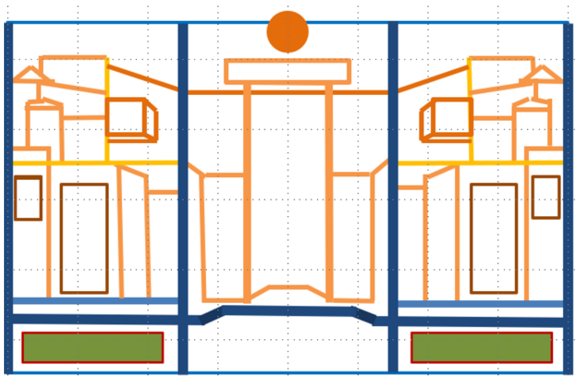

Figure 21. Grid only. Source: the author.

It is also possible that grids were used for placing "built" and landscape elements of a scene, while the circles defined the proportions of people. For example, the center of a scene, as the focus, might be largest with smaller flanking figures on the same ground line. Lastly, grids may have been used in earlier paintings and the circles deployed sometime in the second century, as noted in the Philostratus passage.

5.3.3. Other Applications of the Circle System

At least one example of the modular use of circles in art has survived. The back of the Season Sarcophagus at the Metropolitan Museum of Art, New York, was used like "scratch paper", because it was never meant to be seen. According to Elizabeth Bartman, the artist selected one set of test concentric circles to control the relationships and sizes of the figures on the front of the sarcophagus.[59] This sarcophagus dates to roughly the time of Philostratus.

As the Bartman example shows, concentric circles, unlike "linear perspective", were not restricted to the design of painted "architectural" walls, but could appear in any scene, no matter the subject nor the medium—a topic to be explored elsewhere.

Note that the idea of concentric circles for figured scenes goes back to the description of the "second" shield of Achilles in the *Iliad* (18.478–608). Perhaps even more significant is the use of ring composition (i.e., concentric circles) for the text of the *Iliad* and the *Odyssey*.

5.4. The Vertical Vanishing Axis

5.4.1. Facsimiles Using a Central Vertical Vanishing Axis

I tried designing the same walls with a central vertical vanishing axis.[60] It was such a nightmare that I have no completed examples. I was in a quandary about where to place points on the vertical axis and at what angles to draw the diagonals. Each circle is numbered, so to speak, which enables one to count either from the edge or from the center to produce mirror images. "Arbitrary" decisions by eye for what goes where were easy to make, because the circles provided obvious starting and finishing points. With the vertical vanishing axis, each element had to be individually placed and measured. Keeping bilateral symmetry was complex, because it was no longer a matter of flipping elements from one side to the other, but of making each measurement twice, once for each half. In fact, the precise measuring and layout required for linear perspective are also necessary for a vanishing vertical axis.

Most important of all, however, was my realization that if I began with a vanishing vertical axis and laid down the diagonals in the beginning to guide my placement of the elements, then *all the "pairs" of diagonals* ***must*** *cross the vertical axis together.* Yet, no one has managed to get such uniform agreement within a single wall, when imposing diagonals on the actual wall paintings. The cubiculum from Boscoreale is a typical example (Figure 22). Hence, I believe that it is highly unlikely that a vanishing vertical axis was used—a conclusion reinforced by the next experiment.[61]

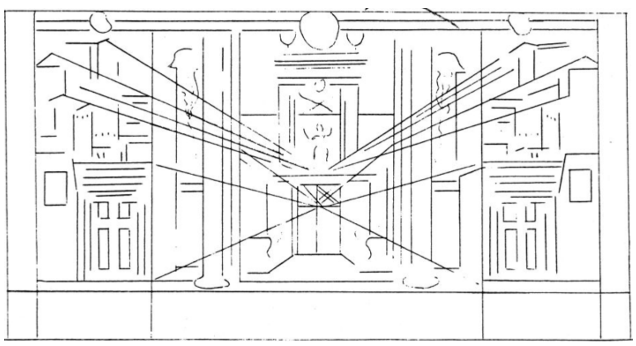

Figure 22. So-called vanishing vertical axis, as applied by Little (1971, plate III, Figure 2).

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59 Bartman (1993) does not mention the Philostratus passage.

60 The single example that Panofsky (pl. 1 on p. 157) cites for a vanishing vertical axis is not from Boscoreale, but is one small section from a wall in the House of Meleager at Pompeii (VI 9, 2.13, tablinum [8], north wall). Naples, Museo Archeologico inv. 9596 (Bragantini and Sampaolo 2009, pp. 282–87 No. 121 and dated to 62–79 CE).

61 See (Raynaud 2016, pp. 161–76 [main discussion]).

5.4.2. Drawing Diagonals for the Vertical Vanishing Axis over My Circle Reconstructions

I analyzed my finished facsimiles the same way that scholars analyze actual wall paintings (see Supplementary Materials S2). Here, I again used Boscoreale as my example (Figure 22). I restored the vertical axis and then drew sets of matching diagonals from "significant" points (Figure 23). The results matched those drawn by others, including some of the near misses. All my facsimiles produced false vanishing vertical axes, because bilateral symmetry by definition must be organized around either a horizontal or, in the case of Roman wall paintings, a vertical axis. Moreover, the diagonal lines seem to vanish only if one considers each diagonal as two separate diagonals joined end to end rather than as a single diagonal. This experiment proved two things. First, the idea of the vanishing vertical axis should vanish. Second, analyzing the "surface geometry" of finished works of art is too subjective to be of value.[62]

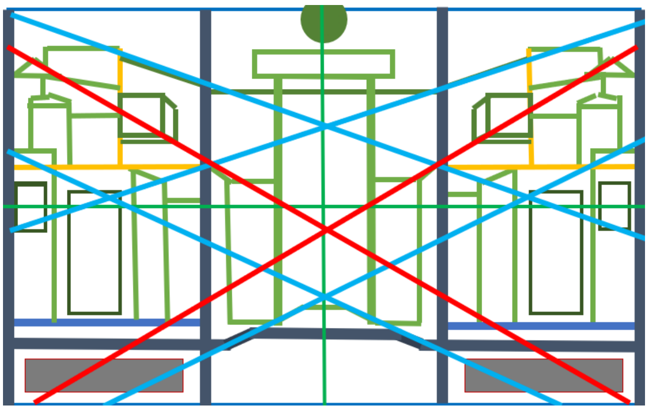

Figure 23. Vanishing vertical axis on facsimile. Source: the author.

5.5. Summary

The passage from Philostratus documents the use of circles in Roman wall painting certainly for his own time (ca. 200 CE) and most likely earlier. His use of "*analogia*", "proportion", links this method of design with that of Vitruvius, who likewise emphasizes proportion ("*scaenographia*" [1.2.2], "Vitruvian man" [3.1], among many). Finding traces of concentric circles or grids is difficult, because they were likely drawn in charcoal and plastered and painted over to achieve the final product. It is clear, however, that either circles or grids or a combination are sufficient for the design of Roman painted walls. At this stage of our knowledge, what was used when and where remains open. We do know, however, that complex systems of design, such as the vanishing vertical axis or linear perspective, are unlikely.

6. Implications

The new interpretations of the two passages from Vitruvius have major implications for our understanding of ancient art, which I can only briefly sketch here. First and foremost, if linear perspective was unknown in classical antiquity, then not only are painting and relief affected but also architecture. Construction of buildings would resemble that of the Middle Ages without precise plans drawn to scale. Second, Pliny the Elder's account of the history of art makes sense. His emphasis on proportion and shading as the major forces in painting need to be taken at face value. In particular,

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[62] Compare especially (Elkins 1991), from the title of which I have taken the term "surface geometry". Yeomans (2011, p. 23) calls this kind of interpretation "epiphenomenal" and says (p. 44) "it is easy to be mesmerized by the number of relationships that can be found, and one can be seduced into an orgy of drawing and the building's supposed magic."

proportion was not just a literary or philosophical issue[63] but directly affected art from the end of the sixth century BCE, if not earlier.[64] Third, the new interpretations fit well with their understanding of optics. Fourth, the dominant scholarly theory that theater was a major influence on Roman wall painting needs to be reconsidered, as well as what *skenographia* was and where it appeared on theaters. Fifth, while "ring" theory, i.e., concentric circles, from Homer on is well known to classicists, it has not been considered for art and how it might organize the way stories are told pictorially.[65]

7. Closing Remarks

Edward R. Murrow (1908–1965), the war correspondent and early television newscaster, said: "The obscure we see eventually. The completely obvious, it seems, takes longer."[66] Many scholars still believe that the Greeks alone—not the Etruscans or the Romans—produced art. This assumption means that any "worthwhile" technique must have its origins in Greek art. Thus, the Renaissance misinterpretation of *skenographia* as "perspective" led inevitably to the conclusion that linear perspective is a Greek invention of the fifth century BCE.

My analysis of the two key passages in Vitruvius has resulted in two radically different interpretations that resolve much of the contradictory evidence and agrees with their understanding of optics. 7.Pr.11 actually describes the major advance in Greek painting of shading and shadows in the later fifth century BCE, which was probably associated with the Greek word *skiagraphia*. The other passage, 1.2.2, about *skenographia* finally makes sense, because it describes the "missing", crucial plan—the definition of the module that governs the relationship between the parts of a building to produce a harmonious whole. In turn, a major and currently disfavored theme of classical art, proportion, needs to be revived.[67] Particularly striking is that Pliny the Elder's coverage in the *Natural History* of proportion in ancient painting matches his emphasis on shading and shadows. Together the two produced art that truly in classical terms was "the imitation of nature" (e.g., Aristotle *Physics* 194a21).

Next, a long-neglected passage from Philostratus explains the system of concentric circles that were used to design Roman wall paintings. Put simply: the system works. It requires only five tools. It is not based on precise measurements, but, as Vitruvius advises, is modular. It is the first proposed system that can be used for entire walls for all three styles. Furthermore, it demonstrates that the idea of the vanishing vertical axis is not the beginning of design but an artifact of the finished design.

Finally, I present this overview of my reinterpretation of two passages in Vitruvius and one in Philostratus not as a conclusion but as a beginning to open discussion.

Supplementary Materials: The following are available online at http://www.mdpi.com/2076-0752/8/3/118/s1, Supplementary Materials S1: Facsimiles. 1. Oplontis; 2. House of the Cryptoporticus; 3. House of Lucretius Fronto; 4. House of the Vettii. Supplementary Materials S2: Tests. 1. Nested squares; 2. Vanishing Vertical Axis on Actual Walls; 3. Vanishing Vertical Axis on Facsimiles.

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63 E.g., Plato famously complained in the *Sophist* (235–36) about the distortions sculptors made in pedimental sculpture so that it would look "right" to viewers from below. He does not use *skenographia or skiagraphia* but *symmetria*.

64 See (Small 2012) on how vase shape affects the portrayal of figures.

65 See (Small 1999, pp. 564–66) on Circe and Odysseus' men on an Attic black-figure cup in Boston (MFA 99.518) and on the Great Trajanic frieze.

66 http://en.wikiquote.org/wiki/Edward_R._Murrow.

67 For an example of the importance of understanding proportion and its effect on how figures look, see (Small 2012).

Conflicts of Interest: The author declares no conflict of interest.

Appendix A Greek and Latin Passages

1. Vitruvius, *De architectura*, 1.2.2 (Late first century BCE)
Item scaenographia est frontis et laterum abscedentium adumbratio ad circinique centrum omnium linearum responsus.
2. Vitruvius, *De architectura*, 7.Preface.11 (Late first century BCE)
Namque primum Agatharchus Athenis Aeschylo docente tragoediam scaenam fecit et de ea commentarium reliquit. Ex eo moniti Democritus et Anaxagoras de eadem re scripserunt, quemadmodum oporteat ad aciem oculorum radiorumque extentionem certo loco centro constituto lineas ratione naturali respondere, uti de incerta re certae imagines aedificiorum in scaenarum picturis redderent speciem et, quae in directis planisque frontibus sint figurata, alia abscedentia, alia prominentia esse videantur.
3. "Aristotle", *On Things Heard*, 801a32–36 (4th–3rd c. BCE)
καθάπερ οὖν καὶ ἐπὶ τῆς γραφῆς, ὅταν τις τοῖς χρώμασι τὸ μὲν ὅμοιον ποιήσῃ τῷ πόρρω τὸ δὲ τῷ πλήσιον, τὸ μὲν ἡμῖν ἀνακεχωρηκέναι δοκεῖ τῆς γραφῆς τὸ δὲ προέχειν, ἀμφοτέρων αὐτῶν ὄντων ἐπὶ τῆς αὐτῆς ἐπιφανείας.
4. "Alexander" of Aphrodisias, *Mantissa* 15, 146.8–29 (3rd c. CE)
[A] οὔτε γὰρ τὸ φῶς ὁμοίως ἐπὶ πάντα τὰ μόρια τοῦ ἀνωμάλου πίπτει διὰ τὸ τὰ μὲν αὐτῶν εἶναι κοῖλα, τὰ δὲ κυρτά, καὶ τὰ μὲν ἐκ πλαγίου τοῦ φωτίζοντος, τὰ δὲ καταντικρύ. διὰ γὰρ αύτας τὰς διαφοράς, κἂν ὁμοιόχρουν ᾖ τὸ ὁρώμενον, τὰ μὲν ἀχλυωδέστερα αὐτοῦ, τὰ δὲ εὐσημότερα φαίνεται, οὕτως δὲ τὰ μὲν εἰσέχοντα, τὰ δὲ ἐξέχοντα ὁραθήσεται. ὃ μιμούμενοι καὶ οἱ ζῳγράφοι, ὅταν βούλωνται ἄνισον δεῖξαι ἐν τῷ αὐτῷ ὂν ἐπιπέδῳ, τὰ μὲν φωτίζουσιν, τὰ δὲ ἐπισκιάζουσιν. οὕτω γὰρ τὰ μὲν ἐξέχοντα, τὰ δὲ εἰσέχοντα αὐτῶν φαίνεται, καὶ ἐξέχοντα μὲν τὰ μᾶλλον πεφωτισμένα, εἰσέχοντα δὲ τὰ ἐπεσκιασμένα. **[B]** μέγεθος δὲ ὁρᾷ καὶ κρίνει τῇ τοῦ κώνου γωνίᾳ τῇ πρὸς τῇ ὄψει συνισταμένῃ. κατὰ κῶνον γὰρ ὁρᾷ τὰ ὁρώμεναγωνίᾳ τῇ πρὸς τῇ ὄψει συνισταμένῃ. κατὰ κῶνον γὰρ ὁρᾷ τὰ ὁρώμενα κορυφὴν μὲν τὴν κόρην ἔχοντα, βάσιν δὲ τὴν ὁρίζουσαν γραμμὴν τό τε ὁρώμενον τοῦ αἰσθητοῦ σώματος καὶ μή. γίνεται δὲ ὁ κῶνος οὗτος οὐ κατὰ ἀκτίνων ἔκχυσιν, ἀλλ' ἀπὸ τοῦ ὁρωμένου. τῆς γὰρ χρόας κινητικῆς οὔσης τοῦ κατ' ἐνέργειαν διαφανοῦς καὶ τῆς ἐν τούτῳ γινομένης ὥσπερ χρώσεως ἐπ' εὐθείας γινομένης. παραπλησίως τῷ φωτὶ παντί τε τῷ καταντικρὺ προσκαθημένης, μάλιστα δὲ τοῖς λείοις καὶ λαμπροῖς προσιζούσης τε καὶ προσλαμπούσης (τοιαύτη δὲ καὶ ἡ κόρη), συνίστανταί τινες πρὸς ταύτῃ κῶνοι ἀπὸ τοῦ ὁρωμένου, οἷοι τὴν ἔμφασιν δέχεσθαι τὴν ἀπ' αὐτοῦ. κατὰ γὰρ κῶνον ἑκάστου τῶν ἐπ' εὐθείας ὁρωμένων τὸ εἶδος τοῦ ὁρατοῦ ἐμφαίνεται. ὧν κώνων ταῖς γωνίαις τὰ μείζω καὶ τὰ ἐλάττω καὶ τὰ ἴσα κρίνει·
NOTE: A and B indicate the division between parts quoted in my text. Furthermore, Section B includes the full Greek text of which I quoted only parts.
5. Porphyry, *Commentary on the Harmonics of Ptolemy*, Düring 70 lines 10–14 (3rd c. CE)
καθάπερ οὖν καὶ ἐπὶ τῆς γραφῆς, ὅταν τις τοῖς χρώμασι τὸ μὲν ὅμοιον ποιήσῃ τῷ πόρρω, τόδε τῷ πλησίον, τὸ μὲν ἡμῖν ἀνακεχωρηκέναι δοκεῖ τῆς γραφῆς, τὸ δὲ προέχειν, ἀμφοτέρων αὐτῶν ὄντων ἐπὶ τῆς αὐτῆς ἐπιφανείας, οὕτω καὶ ἐπὶ τῶν ψόφων καὶ τῆς φωνῆς·
6. Pliny the Elder, *Natural History***,** 35.29. (ca. 23–79 CE)
Tandem se ars ipsa distinxit et invenit *lumen atque umbras*, differentia colorum alterna vice sese excitante. postea deinde adiectus est *splendor*, alius hic quam *lumen*. quod inter haec et *umbras* esset, appellarunt *tonon*, *commissuras vero colorum* et transitus *harmogen*.
7. Philostratus, *Imagines***,** 1.Proem.2.–10 (ca. 170–ca. 215 CE)
ζωγραφία δὲ ξυμβέβληται μὲν ἐκ χρωμάτων, πράττει δὲ οὐ τοῦτο μόνον, ἀλλὰ καὶ πλείω σοφίζεται ἀπὸ τούτου [τοῦ] ἑνὸς ὄντος ἢ ἀπὸ τῶν πολλῶν <ἡ> ἑτέρα τέχνη. σκιάν τε γὰρ ἀποφαίνει …

8. Lucretius, *On the Nature of Things*, 4.426–431 (ca. 98–55 BCE)
Porticus aequali quamvis est denique ductu
stansque in perpetuum paribus suffulta columnis,
longa tamen parte ab summa cum tota videtur,
paulatim trahit angusti fastigia coni,
tecta solo iungens atque omnia dextera laevis
donec in obscurum coni conduxit acumen.
9. Euclid, *Optics*, Definition 2 (ca. 300 BCE)
καὶ τὸ [μὲν] ὑπὸ τῶν ὄψεων περιεχόμενον σχῆμα εἶναι κῶνον τὴν κορυφὴν μὲν ἔχοντα ἐν τῷ ὄμματι τὴν δὲ βάσιν πρὸς τοῖς πέρασι τῶν ὁρωμένων.
10. Plutarch, "*On the Fame of the Athenians*" [*Moralia*] 346a (45–ca. 125 CE)
καὶ γὰρ Ἀπολλόδωρος ὁ ζωγράφος, ἀνθρώπων πρῶτος ἐξευρὼν φθορὰν καὶ ἀπόχρωσιν σκιᾶς, …
11. Vitruvius, *De architectura*, 1.2.2 [immediately preceding No. 1 above] (Late first century BCE)
Ordinatio est modica membrorum operis commoditas separatim universeque proportionis ad symmetriam comparatio. Haec componitur ex quantitate, quae graece poso/thj dicitur. Quantitas autem est modulorum ex ipsius operis membris sumptio e singulisque membrorum partibus universi operis conveniens effectus.
12. Vitruvius, *De architectura*, 1.2.4 (Late first century BCE)
Item symmetria est ex ipsius operis membris conveniens consensus ex partibusque separatis ad universae figurae speciem ratae partis responsus. Uti in hominis corpore e cubito, pede, palmo, digito ceterisque particulis symmetros est eurythmiae qualitas, sic est in operum perfectionibus.
13. Vitruvius, *De architectura*, 3.1.1 (Late first century BCE)
Aedum compositio constat ex symmetria, cuius rationem diligentissime architecti tenere debent. Ea autem paritur a proportione, quae graece analogia dicitur. Proportio est ratae partis membrorum in omni opere totoque commodulatio, ex qua ratio efficitur symmetriarum. Namque non potest aedis ulla sine symmetria atque proportione rationem habere compositionis, nisi uti ad hominis bene figurati membrorum habuerit exactam rationem.
14. Vitruvius, *De architectura*, 3.1.9 (Late first century BCE)
Ergo si convenit ex articulis hominis numerum inventum esse et ex membris separatis ad universam corporis speciem ratae partis commensus fieri responsum, relinqui-tur, ut suspiciamus eos, qui etiam aedes deorum inmorta-lium constituentes ita membra operum ordinaverunt, ut proportionibus et symmetriis separatae atque universae convenientes efficerentur eorum distributiones.
15. Philostratus, *Imagines*, 1.4.2 (ca. 170–ca. 215 CE)
ἡδὺ τὸ σόφισμα τοῦ ζωγράφου. περιβάλλων τοῖς τείχεσιν ἄνδρας ὡπλισμένους τοὺς μὲν ἀρτίους παρέχει ὁρᾶν, τοὺς δὲ ἀσαφεῖς τὰ σκέλη, τοὺς δὲ ἡμίσεας καὶ στέρνα ἐνίων καὶ κεφαλὰς μόνας καὶ κόρυθας μόνας, εἶτα αἰχμάς. ἀναλογία ταῦτα, ὦ παῖ· δεῖ γὰρ κλέπτεσθαι τοὺς ὀφθαλμοὺς τοῖς ἐπιτηδείοις κύκλοις συναπιόντας.

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