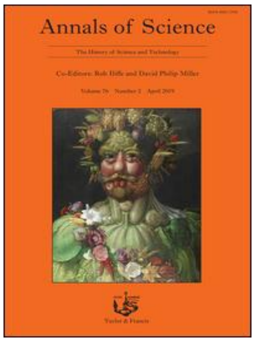


Annals of Science

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tasc20

Observations on Niccolò Tornioli's *The Astronomers*

Susanna Berger & Sara J. Schechner

To cite this article: Susanna Berger & Sara J. Schechner (2021): Observations on Niccolò Tornioli's *The Astronomers*, Annals of Science, DOI: 10.1080/00033790.2021.1957149

To link to this article: https://doi.org/10.1080/00033790.2021.1957149

Published online: 26 Jul 2021.

ANNALS OF SCIENCE
https://doi.org/10.1080/00033790.2021.1957149

Observations on Niccolò Tornioli's *The Astronomers**

Susanna Berger[a] and Sara J. Schechner [b]

[a]Departments of Art History and Philosophy, University of Southern California, Los Angeles, CA, USA; [b]Collection of Historical Scientific Instruments, Department of History of Science, Harvard University, Cambridge, MA, USA

ABSTRACT
Our discussion of Niccolò Tornioli's *The Astronomers* questions some of the traditional identifications of its characters, although we cannot claim to have solved these figures' identities and several remain a mystery. We do present new iconographic interpretations of particular scientific instruments, diagrams, and natural phenomena in the canvas. These novel readings occasionally remain conjectural in part because Tornioli represents these entities in a way that makes it clear that he did not fully comprehend them. The errors and obscurities in Tornioli's painting lead us to two conclusions. First, that his erudite patron Virgilio Spada was unlikely to have been involved in the definition of the painting's iconographies, as he would have objected to Tornioli's crass mistakes and obscure imagery. Second, that these errors and indistinct details should be taken at face value, insofar as they accentuate the difficulties of astronomical observation. Beyond highlighting these challenges, we argue that the painting also visualizes techniques for countering them. Specifically, the canvas would have focused early modern observers' attention on the edifying powers of civil conversations and communal observations with scientific instruments as well as images—including diagrams, celestial maps, and paintings.

ARTICLE HISTORY
Received 13 July 2021
Accepted 13 July 2021

KEYWORDS
Bernardino Spada; Virgilio Spada; Niccolò Tornioli; *Gli astronomi*; Galileo Galilei; visualizing knowledge

1. Introduction

In the summer of 1645, the Oratorian Virgilio Spada (1596–1662) acquired a painting of a debate on astronomy by the Sienese artist Niccolò Tornioli (1598?–1651) and displayed it in the Palazzo Spada, the Roman residence of his older brother, Cardinal Bernardino Spada (1594–1661) (Figure 1).[1] The image, which measures 58.3 by 86 in., is referred to as a painting of 'philosophers' in an account book dated 1644–45 and has since been known by

CONTACT Sara J. Schechner schechn@fas.harvard.edu

*Our names are listed in alphabetical order to reflect our equal contributions to this article.

[1]For a bibliography of the painting, see Marco Ciampolini, *Pittori senesi del Seicento* (Siena: Nuova immagine editrice, 2010), pp. 885–86. See also Giulia Martina Weston, 'After Galileo: The Image of Science in Niccolò Tornioli's Astronomers', *Art History*, 39.2 (2016), 302–17; and Alina Payne, *The Telescope and the Compass: Teofilo Gallaccini and the Dialogue between Architecture and Science in the Age of Galileo* (Florence: Olschki, 2012), pp. 3–6. Unless otherwise noted, all translations are our own.

Figure 1. Niccolò Tornioli. *Gli astronomi*, before 1645. Rome, Galleria Spada.

different titles, among the most enduring of which is *Gli astronomi* (The Astronomers).[2] From the account book we learn that Tornioli sold it directly to Spada along with his *Caino uccide Abele* (Cain Killing Abel) for eighty-five scudi, a relatively modest sum.[3]

Our discussion of *The Astronomers* questions some of the traditional identifications of its characters, although we cannot claim to have solved these figures' identities and several remain a mystery. We do present new iconographic interpretations of particular scientific instruments, diagrams, and natural phenomena in the canvas.[4] These novel readings occasionally remain conjectural in part because Tornioli represents these entities in a way that makes it clear that he did not fully comprehend them. The errors and obscurities in Tornioli's painting lead us to two conclusions. First, that the erudite Virgilio Spada was unlikely to have been involved in the definition of the painting's iconographies, as he would have objected to Tornioli's crass mistakes and obscure imagery. Second, that these errors

[2]Archivio di Stato di Roma (ASR), Fondo Spada Veralli, vol. 829, c. 74: 'A di 8 luglio 1645 s. 60 al S. Niccolò Tornioli per il resto di s. 85 per doi quadri de filosofi e di Cain … ' ('On 8 July 1645, sixty scudi were given to Niccolò Tornioli for the remainder of the eighty-five scudi [owed to him] for the paintings of philosophers and of Cain … ')

[3]*Ibid.* On the great variability of prices in seventeenth-century Italy, see Richard E. Spear and Philip Sohm, *Painting for Profit: The Economic Lives of Seventeenth-Century Italian Painters*. (New Haven: Yale University Press, 2010).

[4]We are cognizant of the anachronism that the employment of 'scientific' in the context of seventeenth-century astronomy implies. We use 'science' and its derivatives as stand ins for such lengthier, but more precise terms as 'natural philosophy' or 'mathematical natural philosophy'.

and indistinct details should be taken at face value, insofar as they accentuate the difficulties of astronomical observation. In seventeenth-century Italy, such difficulties ranged from the frustrations of making sense of what was seen through a telescope to the complications of seeing due to weather. Beyond highlighting the difficulties of astronomical observation, we argue that the painting also visualizes techniques for countering those challenges. Specifically, the canvas would have focused early modern observers' attention on the edifying powers of civil conversations and communal observations with scientific instruments as well as images—including diagrams, celestial maps, and paintings.

Much was questioned in seventeenth-century astronomy and of course a number of thinkers were subject to censorship.[5] Convivial debates on astronomy and collective observations in courtly settings not only strengthened astronomical observation and understanding, but they also helped to elevate the epistemological prestige of the discipline by providing settings for astronomers to justify and promote the cognitive status of their field.[6] As Robert Westman and others have stressed, in early modern Europe, the intellectual and social status of astronomers and other mixed mathematicians underwent a major transformation.[7] In the hierarchy of university disciplines of this period, mathematicians, who studied the quantitative characteristics of natural phenomena, were initially ranked below philosophers, who examined the causes of natural phenomena and were rewarded by higher salaries and greater professional renown. By participating in courtly debates and by identifying themselves with philosophers, early modern astronomers, like Galileo Galilei (1564–1642), elevated the position of their field and legitimated the employment of mathematics as an instrument to understand the causes of natural phenomena's physical characteristics.[8] The reference to philosophers in the original title of Tornioli's canvas cited in the account book from 1644–45 reflects the fraught status of astronomy as mixed mathematics or natural philosophy in this transformative and complex period.[9]

We begin with an overview of the painting, in which we discuss previous scholars' accounts of its characters and composition. The next section surveys some of the ways in which conversation and communal observation with scientific instruments and images served to educate eyes in the early modern era. We then probe elements of the canvas with our own (often conjectural) interpretations.

[5]On the censorship of astronomy, see Owen Gingerich, *An Annotated Census of Copernicus'* De revolutionibus *(Nuremberg, 1543 and Basel, 1566)* (Leiden: Brill, 2002).

[6]Mario Biagioli, *Galileo, Courtier: The Practice of Science in the Culture of Absolutism* (Chicago: University of Chicago Press, 1993).

[7]Robert Westman, 'The Astronomer's Role in the Sixteenth Century: A Preliminary Study', *History of Science*, 18 (1980), 105–47 (p. 111).

[8]Jim Bennett, 'The Mechanical Arts', in *The Cambridge History of Science*, ed. by Katharine Park and Lorraine Daston (Cambridge, UK : Cambridge University Press, 2006), 673–95 (p. 685); Mario Biagioli, *Galileo, Courtier*.

[9]Concerning the telescope as an instrument for natural philosophy, see Bennett, 'The Mechanical Arts', p. 685.

2. The Astronomers

In Tornioli's densely crowded scene, seven three-quarter length men and two three-quarter-length women converse in a shallow, outdoor space, while employing a range of scientific instruments and images to make observations. The figures are jammed horizontally, and they also appear pressed right up against the picture plane.[10] On the painting's right edge, for instance, the lower back of the youth who peers through a telescope is cropped by the frame, while his left hand reaches out of the fictive space of the painting into the observer's realm (Figure 2). This youth, according to art historian Federico Zeri, derives from the *Narcissus* (c. 1599–1620), which was first attributed to Michelangelo Merisi da Caravaggio (1571–1610) in 1916 by Roberto Longhi (1890–1970) (Figure 3).[11] Both figures are partially undressed, with billowing shirtsleeves exposed along with dramatically-lit knees. Further similarities can be located in the profile views and the figures' states of intense absorption, although a definitive connection between these two paintings remains to be demonstrated.[12]

Other Caravaggesque fingerprints abound in *The Astronomers*: its three-quarter length format, the dramatic *chiaroscuro* lighting, the multiple hands that reach in the observer's direction, and the portrayals of figures in the midst of action. These stylistic choices may stem from Tornioli's Sienese background. Scholars have posited that he likely developed his style in relation to the two leading Caravaggisti of his hometown: Francesco Rustici (1592–1625) and Rutilio Manetti (1571–1639).[13] Two canvases attributed to the later may well have provided inspiration to Tornioli's painting: *Due profeti* (Two Prophets) now in Galleria Nazionale d'Arte Antica and *Christ Disputing with the Elders* held today by the Museum & Gallery at Bob Jones University (Figures 4 and 5). Like *The Astronomers*, these works show men in stark *chiaroscuro* lighting, debating with open books, in close proximity to one another.

In *The Astronomers*, a powerful diagonal extends from the creased book in the lower left that the elderly, bearded man clutches in his veiny, right hand

[10]Alina Payne notes that the figures are 'almost spilling over into the viewer's space'. Payne, *Telescope and Compass*, p. 1.

[11]Federico Zeri, *La galleria Spada in Roma* (Roma: Libreria dello Stato, 1952), p. 21. Zeri, *La Galleria Spada in Roma: Catalogo dei dipinti* (Florence: Sansoni, 1954), pp. 136–37. Roberto Longhi, 'Gentileschi, padre e figlia', *L'Arte*, 19 (1916), 245–314. On the *Narcissus*'s attribution debates, see Gianni Papi, 'Narciso', in *Michelangelo Merisi da Caravaggio: Come nascono i capolavori*, ed. by Mina Gregori (Milan: Electa, 1991), p. 359; and Rosella Vodret, *Caravaggio* (Milan: Silvana, 2009), pp. 242–47. On the *Narcissus*, see also Susanna Berger, 'From Narcissus to Narcosis', *Art History*, 43.3 (2020), 612–39.

[12]On absorption in Caravaggio's art, see Michael Fried, *The Moment of Caravaggio* (Princeton: Princeton University Press, 2010).

[13]Anna Matteoli, 'Due inedite pitture barocche su temi biblici', *Bollettino della Academia degli Euteleti*, 68 (2001), 143–73 (p. 143); Salvador Salort-Pons, 'La llegada de Niccolò Tornioli a Roma y el malogrado mecenazgo del abad Borromeo', *Antologia di Belle Arti. Studi Romani*, 67–70 (2004). 9–13 (p. 9); and Marco Ciampolini, 'Niccolò Tornioli', in *Bernardino Mei e la pittura barocca a Siena*, ed. by Fabio Bisogni and Ciampolini (Siena: Palazzo Chigi Saracini, 1987), pp. 109–21 (p. 109). Zeri also notes the impact of Manetti on Tornioli (*La Galleria Spada in Roma: Catalogo dei dipinti*, p. 136).

Figure 2. Downward gazing youth with telescope. Tornioli. Detail from *Gli astronomi*. Rome, Galleria Spada.

to the astronomical phenomena in the heavens in the upper right to which the younger, central man points. Zeri and more recent art historians have identified the older figure as Aristotle (384–22 BCE), largely because they believe that the

Figure 3. Caravaggio (attributed to). *Narcissus*, c. 1599–1620. Rome, Galleria Nazionale d'Arte Antica, Palazzo Barberini.

book he holds is open to an Aristotelian model of the universe (Figure 18).[14] We challenge this logic by showing below that the diagram is Ptolemaic. Some also identify the elderly figure with Aristotle because they see similarities to the philosopher's depiction by Stefano della Bella (1610–64) in his frontispiece for *Dialogo sopra i due massimi sistemi del mondo* (Dialogue on the Two Chief World Systems, 1632), by Galileo (Figure 6).[15] In della Bella's print, Copernicus (1473–1543) stands on the right and debates with Aristotle on the left and Ptolemy (d. 160 CE), in the centre. The similarities are little

[14]Zeri, *La Galleria Spada in Roma: Catalogo dei dipinti*, p. 137. Weston, 'After Galileo', p. 304. Zeri also considers the figure to be the Aristotelian philosopher Averroes (1126–1198).
[15]Maria Lucrezia Vicini, 'Cat. n. 153', in *Il cannocchiale e il pennello: nuova scienza e nuova arte nell'età di Galileo* (Florence: Giunti, 2009), p. 388.

Figure 4. Rutilio di Lorenzo Manetti (attributed to). *Due profeti*. Rome, Galleria Nazionale d'Arte Antica.

Figure 5. Rutilio di Lorenzo Manetti (attributed to). *Christ Disputing with the Elders*, sixteenth or seventeenth century. Greenville, South Carolina, Museum & Gallery.

more than both men having long, grey beards and shiny bald heads with wavy, grey hair at the sides and back, and perhaps their stance, insofar as both men reach into the space of the representations, albeit with different hands. We find this reasoning intriguing, if inconclusive; there is also no evidence that Tornioli ever saw the frontispiece in Galileo's banned book, which was not in Bernardino or Virgilio Spada's library, although Virgilio did correspond about the *Dialogo* in letters to Leopoldo de Medici (1617–1675) in August 1650.[16] We, therefore, choose not to guess whether Tornioli intended the elder man to be Aristotle or Ptolemy, but we do concur that he represents ancient astronomy. For clarity in this paper, we will call him the Ancient Astronomer.

Zeri identifies the younger, central figure in *The Astronomers* as Copernicus.[17] We must point out, however, that the young man does not resemble any known portraits of Copernicus, such as that by Jacob van Meuren (1617/18–79) (Figure 7). At best, both figures wear fur-lined cloaks, which is hardly conclusive. We, therefore, choose to call the younger figure the New Astronomer, since he represents the so-called 'new astronomy' of Copernicus, Tycho, Kepler, and Galileo. He is not bound to traditional texts; he observes new things in the heavens that challenge ancient authority.

Thus, in Tornioli's painting, the artist has given the New Astronomer an open mouth and pointing arm to show him in the act of explaining the significance of the celestial phenomena to the Ancient Astronomer. Dumbstruck, the latter grabs the New Astronomer's forearm in an intense, uncivil gesture of frustration. The Ancient Astronomer's worn and cumbersome tome—upside down (for the painting's viewer)—underlines his intellectual debility.

The diagonal in *The Astronomers* is emphasized by the three-quarter stances of the New and Ancient Astronomers, as well as by the arm and hand of the Ancient Astronomer, and by the hands of the woman that rest on the celestial globe. She is often identified as Astronomy, a label that we accept since she appears to take possession of the globe.[18] Astronomy leans towards the Ancient Astronomer and points his way. The woman to the right holding a square and dividers is recognized as Geometry, since these instruments are her conventional attributes.[19]

[16]For an inventory (dated 1661) of Bernardino Spada's library, see ASR, Notai Tribunali A. C., vol. 5933, fols. 760r–775v. For inventories of Virgilio Spada's library, see ASR, Nota de i manuscritti legati in libri che esistevano nella libreria di Monsignor Virgilio Spada nella Chiesa Nuova, 30 agosto 1662, Fondo Archivistico Spada Veralli, vol. 379; ASR, Inventario dei libri, Fondo Archivistico Spada Veralli, vol. 494; and Biblioteca Vallicelliana, Indice dei libri del P. Virgilio Spada, Z. 109. According to Giuseppe Finocchiaro, the Biblioteca Vallicelliana inventory was done quickly before Virgilio Spada's death in 1662. See Finocchiaro, *Il Museo di curiosità di Virgilio Spada. Una raccolta romana del Seicento* (Rome: Fratelli Palombi, 1999), p. 20 n. 33 and p. 117. For the correspondence regarding the Galileo's writings, see ASR, Fondo Spada Veralli, vol. 235, p. 163; and ASR, Fondo Spada Veralli, vol. 235, pp. 171-73.

[17]Zeri, *La Galleria Spada in Roma: Catalogo dei dipinti*, p. 137.

[18]Ciampolini, 'Niccolò Tornioli', p. 114. Payne, *Telescope and Compass*, p. 2.

[19]Payne, *Telescope and Compass*, p. 2. Examples of Geometry personified with dividers and square and Astronomy with a celestial globe are numerous in series of the Seven Liberal Arts from the late medieval period onward.

Figure 6. Stefano della Bella. Frontispiece to first edition of Galileo Galilei, *Dialogo sopra i due massimi sistemi del mondo*, Florence, 1632. Florence, Biblioteca Nazionale Centrale.

As for the remaining figures in the painting, Zeri and others have identified the man in military garb on the left as Ptolemy or Alexander the Great (356–323 BCE),[20] and the bearded figure on the right edge of the

[20]Zeri, *La Galleria Spada in Roma: Catalogo dei dipinti*, p. 137; Payne, *Telescope and Compass*, p. 2; and Roberto Cannatà, 'Nicolò Tornioli', in *Laboratorio di restauro 2: Roma, Salone di Palazzo Barberini*, exh. cat., ed. by

Figure 7. Jacob van Meurs. *Portrait of Copernicus*, 1633–79. Engraving. London, British Museum. © The Trustees of the British Museum.

canvas as Galileo.[21] We have nothing to add to these speculations, but underscore that the military figure is in the realm of ancient learning and the other, if he be Galileo, is appropriately in the realm of the new astronomy. The identities

Dante Bernini (Rome: Palombi, 1988), pp. 174–81 (p. 177). Giulia Martina Weston argues that this figure resembles representations of Alexander the Great. Weston, 'After Galileo', p. 304.

[21]Payne, *Telescope and Compass*, p. 28. Weston, 'After Galileo', p. 304. Anna Matteoli raises the possibility that the painting was imagined as an homage to Galileo. Matteoli, 'Due inedite pitture', p. 153.

of the youth with the telescope and of the older man peering over his shoulder, in a stance not unlike those of the disciples in Caravaggio's *Incredulity of Saint Thomas* (1601–02), also remain unresolved. According to Giulia Martina Weston, the man who gazes out at the observer and stands to the right of Geometry could be Tornioli himself. More evidence is needed, however, to confirm this figure's identity conclusively.[22]

Despite our questions concerning the positive identification of the figures, we agree with scholars that the painting visualizes a debate between representatives of ancient and early modern astronomy.[23] According to Maria Lucrezia Vicini, the composition is derived from della Bella's frontispiece for the *Dialogo* (see Figure 6).[24] Although Alina Payne agrees with Vicini's suggestion, we prefer her opinion that Raphael's *School of Athens* (1509-11) was a more likely source for both the painting and frontispiece.[25] As a banned book, which was not present in Bernardino or Virgilio Spada's libraries, the *Dialogo* was neither easily available to Tornioli nor a safe model to follow.[26] Inga Söderlund also recognizes Raphael's work as an inspirational source, but situates Tornioli's dynamic painting in the genre of illustrated title pages and frontispieces that adorned many seventeenth-century astronomical books. Like the artistic tradition of gathering saints of different centuries in sacred conversation on altarpieces, famous astronomers were assembled with their books and instruments in scenes of debate at the beginnings of texts.[27]

According to Payne, another source for the painting lies in its depiction of science as an activity involving discussion or *disputà*.[28] In her studies of the Sienese polymath Teofilo Gallaccini (1564–1641), a friend of Tornioli, Payne notes that in Gallaccini's treatise on astronomy, he describes a stargazing event on the rooftop loggia of the palace of the Archbishop of Siena, Ascanio Piccolomini (1590–1671).[29] Over the course of six nights in the summer of 1633, a group of Piccolomini's friends (including Galileo and Gallaccini) looked at the moon through a telescope. Although we know that Tornioli visited Siena during the summer of 1633, no information indicating his presence at this observational gathering has been found; nevertheless, Payne

[22]Weston, 'After Galileo', p. 304.
[23]See, for instance, Vicini, 'Cat. n. 153'; Cannatà, *Galleria di Palazzo Spada: Roma* (Rome: Istituto Poligrafico e Zecca dello Stato, 1995); Weston, 'After Galileo', p. 303.
[24]Vicini, 'Cat. n. 153', p. 388.
[25]Payne, *Telescope and Compass*, pp. 2–3 n. 3.
[26]Regarding Virgilio's correspondence on Galileo's *Dialogo* with Leopoldo de Medici, see note 16 above.
[27]Inga Elmqvist Söderlund, *Taking Possession of Astronomy: Frontispieces and Illustrated Title Pages in 17th-Century Books on Astronomy* (Stockholm: Centre for the History of Science of the Royal Swedish Academy of Sciences, 2010), pp. 281-287, 328. The manifold, elaborate title engravings in seventeenth-century astronomical tracts testify to the rich connections among visual representations and astronomy in this period. These frontispieces often functioned as powerful, encoded summaries of the contents presented in the ensuing text and served to legitimize an author's perspective. Volker R. Remmert, *Picturing the Scientific Revolution*, trans. Ben Kern (Philadelphia: Saint Joseph's Press, 2009).
[28]Payne, *Telescope and Compass*, pp. 3–30.
[29]*Ibid.*, p. 25. Payne, 'Introduction', in *Vision and Its Instruments*, ed. by Payne (University Park, PA: Pennsylvania State University Press, 2015), pp. 1–9 (p. 1).

makes a compelling case for the similarity between the experience of communal observation on the loggia and the one shown in *The Astronomers*.[30]

Our essay on *The Astronomers* builds on these important scholarly contributions insofar as we agree, as noted above, that the painting illustrates the critically important role of discussion and communal observation in the study of the heavens. We, however, add that the work simultaneously accentuates the centrality of scientific instruments and images in guiding the observation and understanding of early modern astronomy. Following this line of thought, *The Astronomers* should also be situated in relation to paintings of collections, such as *The Linder Gallery Interior*.[31] As Michael John Gorman and Alexander Marr have shown, the German merchant Peter Linder, who studied mathematics under Mutio Oddi (1569–1636), commissioned and owned this painting in oil on copper that was probably made when both men were living in Milan between 1621 and 1625.[32] Like *The Astronomers*, *The Linder Gallery Interior* displays a celestial globe, instruments of observation (from an astrological geniture to a cross staff that was to be employed for measurements in astronomy), and images of the cosmos. More precisely, it presents diagrams of the Ptolemaic, Copernican, and Tychonic world systems. Another painting that conjoins themes of collecting and astronomical observation is the portrait of the heir of Corfe Castle, John Bankes, and his teacher Dr Maurice Williams that was created in 1643–44 by Francis Cleyn (1582–1658).[33] On a table near the left edge of this canvas lie a telescope, a globe, and an open book that upon closer inspection displays the frontispiece to Galileo's *Dialogo*. Cleyn's representation of teacher and student with this printed image calls attention to the important functions of prints and drawings in early modern pedagogy more generally.[34] We are not claiming that *The Linder Gallery Interior* or Cleyn's painting inspired Tornioli directly; in fact, it is probable that he saw neither work. Rather, we merely wish to present *The Astronomers* in relation to paintings of its era that also evince the rich interconnections among astronomy, prints, drawings, and scientific instruments.

[30]Payne, *Telescope and Compass*, p. 27. Payne, 'Introduction', p. 2.

[31]For a reproduction and discussion of this painting, see Alexander Marr, *Between Raphael and Galileo: Mutio Oddi and the Mathematical Culture of Late Renaissance Italy* (Chicago: University of Chicago Press, 2011), pp. 190–214; and Michael John Gorman and Marr, '"Others See It Yet Otherwise": Disegno and Pictura in a Flemish Gallery Interior', *The Burlington Magazine*, 149.1247 (2007), 85–91.

[32]Gorman and Marr, '"Others See It Yet Otherwise"', pp. 85–91.

[33]For a recent, in-depth discussion of this painting, see J.L. Heilbron, *The Ghost of Galileo in a Forgotten Painting from the English Civil War* (Oxford: Oxford University Press, 2021).

[34]Throughout seventeenth-century Europe, visual representations and acts of drawing became crucial instruments in the teaching of natural philosophy (as well as other disciplines), as evinced by the elaborate illustrated thesis prints created for students' disputations as well as by the prints and drawings integrated into philosophy students' lecture notebooks. See Louise Rice, 'Jesuit Thesis Prints and the Festive Academic Defense at the Collegio Romano', in *The Jesuits: Cultures, Sciences, and the Arts, 1540–1773* (Toronto: University of Toronto Press, 1999), pp. 148–69; and Berger, *The Art of Philosophy: Visual Thinking from the Late Renaissance to the Early Enlightenment* (Princeton, NJ: Princeton University Press, 2017).

3. Educating the eyes through conversation and communal observation with scientific instruments and images

Over the course of the sixteenth, seventeenth, and eighteenth centuries, observation came to be theorized and celebrated in letters, manuals, treatises, books, and articles concerning a broad range of fields from the visual arts to optics, botany, anatomy, and astronomy.[35] In the process, individuals recognized the importance of educating their eyes in the company of learned viewers. By means of communal acts of observation, by witnessing virtually or in person, individuals were trained to see things critically and in an informed manner. Virtual collectives of observers–generally elite men scattered across broad spatiotemporal networks–shared and synthesized their findings in letters, journals, and books.[36] Like Raphael's *School of Athens*, *The Astronomers* shows a community of observers engaged in an imagined conversation.[37] The painting illustrates a collective mode of looking, discussing, and learning common to the time among people who were privileged to visit museums, cabinets of curiosities, botanical gardens, anatomical theatres, private galleries, libraries, printing houses, bookstores, courts, and academies.[38]

The function of orality in the production of scientific knowledge has often been overlooked in the history of science, in part due to the ephemeral nature of utterances.[39] Yet in recent years scholars have found increasing amounts of evidence concerning the importance of oral culture in disseminating and shifting early modern scientific understanding.[40] For example, scholars have called attention to the critical function of artisans and craftsman in the generation of novel scientific understanding; often this artisanal knowledge

[35]Daston, 'On Scientific Observation', *Isis*, 99.1 (2008), 97–110. For a study of observational practices in early modern anatomy and medical botany, see Sachiko Kusukawa, *Picturing the Book of Nature: Image, Text, and Argument in Sixteenth-Century Human Anatomy and Medical Botany* (Chicago: University of Chicago Press, 2012).
[36]As argued by Daston, 'The Empire of Observation, 1600–1800', in *Histories of Scientific Observation*, ed. by Daston and Elizabeth Lunbeck, (Chicago: University of Chicago Press, 2011), pp. 81–113 (p. 81).
[37]See Payne, *Telescope and Compass*, p. 3–6.
[38]For other groups of elite people, who are being led in seeing and learning, consider the 1667 etching by Giuseppe Maria Mitelli (c. 1634–1718) of the Bolognese collection of Ferdinando Cospi (1606–1686) (British Museum, 1852,0612.471) or a 1610 etching by Willem van Swanenburg (1580–1612) after Jan Cornelis Woudanus (c. 1570–1615) of the anatomy theatre of the University of Leiden (British Museum, 1875,0814.738). Concerning these venues and their relation to the production of natural knowledge, see Park and Daston, eds., *The Cambridge History of Science, Vol. 3, Early Modern Science* (Cambridge: Cambridge University Press, 2006), Part II.
[39]As noted in Monica Azzolini, 'Talking of animals: whales, ambergris, and the circulation of knowledge in seventeenth-century Rome', *Renaissance Studies*, 31.2 (2017), 297–318 (299).
[40]For recent studies of the culture of orality, see Azzolini, 'Talking of animals', pp. 297–318; Adam Fox, *Oral and Literate Culture in England, 1500–1700* (Oxford: Oxford University Press, 2000); Fox and Daniel Woolf, eds., *The Spoken Word: Oral Culture in Britain, 1500–1850* (Manchester: Manchester University Press, 2002), pp. 1–51; Brian Richardson, 'Manuscript, Print, Orality and the Authority of Texts in Renaissance Italy', in *Authority in European Book Culture 1400–1600*, ed. by Pollie Bromilow (Aldershot: Ashgate, 2013), pp. 15–29; Stefano Dall'Aglio, Luca Degl'Innocenti, Richardson, Massimo Rospocher, and Chiara Sbordoni, eds., *Oral Culture in Early Modern Italy: Performance, Language, Religion*, special issue of *The Italianist*, 34.3 (2014); Degl'Innocenti, Richardson, and Sbordoni, eds., *Interactions between Orality and Writing in Early Modern Italian Culture* (London: Routledge, 2016); Dall'Aglio, Richardson, and Rospocher, eds., *Voices and Texts in Early Modern Italian Society* (London: Routledge, 2017); and Elizabeth Yale, *Sociable Knowledge: Natural History and the Nation in Early Modern Britain* (Philadelphia: University of Pennsylvania Press, 2016), 89–115.

was disseminated through spoken discourse.[41] Moreover, speech was at the core of pedagogy in early modern European universities, convents, and colleges, where students were trained to participate in regular oral examinations called disputations.[42]

Conduct manuals such as Stefano Guazzo's (1530–93) *La civil conversazione* (Civil conversation, 1574) offered further advice on how to behave in oral exchanges, which were understood to be necessary for the acquisition of knowledge.[43] Tornioli may well have had the opportunity to consult the copy of Guazzo's manual held in Bernardino Spada's library.[44] According to one of Guazzo's interlocutors, civil conversation involves 'an honest, virtuous, and sociable Kind of Living in the World'.[45] In seventeenth-century England, virtue marked the trustworthiness of a knowledge source, as Steven Shapin has argued.[46] We can deduce from Guazzo's handbook that in early modern Italy as well, a gentleman's virtue was relevant to establishing his reliability in intellectual exchanges.

If the role of scientific instruments from the telescope to the microscope in the study of nature has often been acknowledged, scholars have only in recent years called attention to the roles of images and the practice of drawing and sketching during both private and collective observational practices. In the fifteenth, sixteenth, and seventeenth centuries, as paper was produced in greater quantities and with advances in printing techniques, images on paper, in particular, played a key role in helping observers to document, disseminate, and observe natural phenomena. Leonardo da Vinci (1452–1519) is often celebrated for the manifold ways in which he reflected and noted what he observed by sketching on paper. His notebooks are replete with drawings testifying his personal observations and his broad-ranging pursuits in natural philosophy, such as his studies of breathing instruments meant to be used underwater.[47]

As Sachiko Kusukawa has demonstrated, printed images played a key role during group visits to anatomy theatres and botanical gardens. They helped professors to convey their arguments about bodies and plants clearly to others and assisted spectators who were observing entities first-hand.[48] When a particular

[41]Pamela Smith, *The Body of the Artisan: Art and Experience in the Scientific Revolution* (Chicago: University of Chicago Press, 2004).

[42]Concerning the history of orality in the intellectual realm and oral training in classrooms, see Françoise Waquet, *Parler comme un livre. L'oralité et le savoir (XVIe-XXe siècle)* (Paris: Albin Michel, 2003), pp. 73, 93, and 167.

[43]On civil conversation, see Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (Berkeley: University of California Press, 1994), pp. 104–46; *Stefano Guazzo e la civil conversazione*, ed. by Giorgio Patrizi (Rome: Bulzoni editore, 1990).

[44]See ASR, Notai Tribunali, A.C. vol. 5933, f. 773r. See also Weston, 'Universal Knowledge and Self-Fashioning: Cardinal Bernardino Spada's Collection of Books I', in *Libraries, Books, and Collectors of Texts, 1600-1900*, ed. by Annika Bautz and James Gregory (New York: Routledge, 2017).

[45]The translation, which is not literal, is from Stefano Guazzo, *The Art of Conversation* (London, 1738), p. 38. Guazzo, *La civil conversazione* (Venice, 1596), p. 30: 'la conversatione civile, sia honesta, lodevole, & virtuosa'.

[46]Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth-Century England* (Chicago: University of Chicago Press, 1994).

[47]Leslie A. Geddes, *Watermarks: Leonardo da Vinci and the Mastery of Nature* (Princeton, NJ: Princeton University Press, 2020).

[48]Kusukawa, *Picturing the Book of Nature*. Kusukawa, 'The Uses of Pictures in the Formation of Learned Knowledge: The Case of Leonhard Fuchs and Andreas Vesalius', in *Transmitting Knowledge: Words, Images, and*

anatomical or botanical feature was hard to discern, a print could serve as a map to find it and place it in context.[49] In the 1540s, Vesalius is known to have made use of prints during his public dissections at the University of Bologna.[50] Woodcuts of body parts assisted the anatomist in demonstrating details that were hard to observe clearly in messy and crowded dissections. They also made it possible for him to show students representations of the ideal anatomical specimen. The medical botanist Fuchs similarly encouraged students to observe nature directly with the aid of prints. In 1545 he released an octavo edition of his herbal that could be taken outside and used as a field guide (unlike the earlier edition, which was too cumbersome to be carried around a botanical garden).[51] For Fuchs, as for Vesalius, prints were crucial in guiding the eyes of observers so that they could see and recognize the entities under inspection as well as distinguish variations in the particular from the idealized forms of the parts.[52]

Scholars have also stressed how Galileo's skills as a maker and observer of images allowed him to refine his astronomical observations through scientific instruments, like the telescope.[53] His mastery of drawing, water-colouring, perspective, and his schooled eye made it possible for him to visualize in 1609 the phases of the moon with its mountainous surface in a famous set of seven sepia drawings held today in the Biblioteca Nazionale Centrale in Florence. Galileo's ability to record what he observed visually, in turn, became essential for other observers' to comprehend his findings more clearly. Later visualizations of the moon, such as those in the *Selenographia, sive, Lunae descriptio* (Selenography, or description of the moon, 1647) by Johannes Hevelius (1611–1687) were also designed to educate reader-observers to refine their observational skills; as Kathrin Müller has argued, Hevelius trained reader-observers of his text not to misunderstand its visual representations as unmediated depictions of the moon.[54]

The critical role of prints as tools of observational science in the early modern period can help us to contextualize the actions of the youth, who peers downwards through his telescope in Tornioli's painting (see Figure 2). This figure has perplexed scholars, because he does not look up at the heavens but studies the lines and constellations printed on the celestial

Instruments in Early Modern Europe, ed. by Kusukawa and Ian Maclean (Oxford: Oxford University Press, 2006), pp. 73–96.

[49]Kusukawa, *Picturing the Book of Nature*. Kusukawa, 'The Uses of Pictures'.

[50]See the report of a student named Baldasar Heseler: *Andreas Vesalius' First Public Anatomy at Bologna 1540: An Eyewitness Report by Baldasar Heseler*, ed. by Ruben Eriksson (Uppsala: Almquist & Wiksells, 1959), pp. 236 f. See also Kusukawa, 'The Uses of Pictures', p. 90.

[51]Leonhart Fuchs, *Primi de stirpium historia commentariorum tomi vivae imagines, in exiguam angustioremque formam contractae* (Basel: Michael Isingrin, 1545). *The Great Herbal of Leonhart Fuchs*, ed. by Frederick G. Meyer et al, 2 vols. (Stanford: Stanford University Press, 1999), I, pp. 674–77.

[52]Kusukawa, *Picturing the Book of Nature*. Kusukawa, 'The Uses of Pictures'.

[53]See, for instance, Samuel Y. Edgerton, 'Galileo, Florentine "Disegno" and the "Strange spottednesse" of the Moon', *Art Journal*, 44 (1984), pp. 225–32.

[54]Kathrin Müller, 'How to Craft Telescopic Observation in a Book: Hevelius's *Selenographia* (1647) and its Images', *Journal of the History of Astronomy*, 41 (2010), 355–79.

globe.[55] It is not enough to say the boy is looking down because the artist might have been inspired by the *Narcissus* attributed to Caravaggio. In the context of communal observational practices (discussed above), the boy can be seen as playful and in need of the elders to guide him in the proper way to observe the sky. But it could also be that he is using a low-power telescope as a compound magnifier at shorter range. Small Galilean telescopes of the period could examine nearby things.[56] Indeed, the Venetian nobleman Giovanni Francesco Sagredo (1571–1620), writing to Galileo on 28 July 1618, stated that he often employed 'short telescopes' (*cannoncini corti*) to look at paintings, under which scrutiny 'the well-made [pictures] represent nature, and the others greatly show themselves to be imperfect'.[57] The youth's strange behaviour might not be so strange after all. He draws our attention to the globe and its place in the civil conversation. Just as Fuchs, Vesalius, Galileo, and Hevelius used woodcuts as instructional aids in the fields of botany, anatomy, and astronomy, the boy peers at the globe through his telescope in order to make better sense of the structure of the heavens. It is a star chart for finding one's way among the constellations of the night sky.

Use of a low-power telescope to examine pictures of nature better, as Sagredo advised, was akin to early uses of the microscope to probe minute details of nature or artifice unseen by the naked eye, insofar as both instruments magnified things at close range through the interposition of lenses held in draw tubes. Although the arrangement of lenses differed and microscopes typically had tripods, microscopes and telescopes outwardly appeared similar and both could also be handheld. Indeed, we have discovered that such a microscope belonged to Virgilio Spada and survives today in the Museo Astronomico e Copernicano of the Astronomical Observatory of Rome.[58] It is similar to the

[55]Most recently, Giulia Martina Weston has expressed confusion over this figure's behaviour. Weston, 'After Galileo', pp. 304, 315. Weston, *Niccolò Tornioli (1606–1651): Art and Patronage in Baroque Rome* (Rome: Editoriale Artemide, 2016), p. 129.

[56]A possible example is an English telescope, 1650-1675, having three draw tubes with ferrules, 9.1-23.6 in. long and 1.4 in. in diameter, in the Louwman Collection of Historic Telescopes, The Hague; P. J. K. Louwman and H. J. Zuidervaart, *A Certain Instrument for Seeing Far: Four Centuries of Styling the Telescope Illustrated by a Selection of Treasures from the Louwman Collection of Historic Telescopes* (Wassenaar: Louwman, 2013), cat. no. 22, p. 40. The authors thank Huib Zuidervaart and Peter Louwman for discussion on telescopes that serve as magnifiers of objects at close range.

[57]'Hora in questa città si fanno alcuni cannoncini corti, di due terzi di quarta, assai buoni. Io li uso per vedere pitture da vicino. Le ben fatte rapresentano il naturale, et l'altre maggiormente si scoprono imperfette'. Galilei, *Le Opere* …, ed. by Antonio Favaro, 20 vols. (Florence: G. Barbèra, 1890–1909), no. 1335, vol. XII, p. 401. Cited in Lucia Tongiorgi Tomasi, 'Galileo, le arti, gli artisti', in *Il cannocchiale e il pennello: nuova scienza e nuova arte nell'età di Galileo*, ed. by Tomasi and Alessandro Tosi (Florence: Giunti, 2009), pp. 20–43 (p. 34).

[58]Virgilio Spada's microscope is very similar to the telescope in the painting. It is red and fashioned of pasteboard; has three draw tubes; and is about 14.2 in. long with a maximum diameter of 2 in. The original lenses were removed a century ago. A key difference is a crude metal tripod base. An 1886 inventory (made when the Biblioteca Vallicelliana transferred about forty of Virgilio's instruments to the Museo Astronomico e Copernicano in Rome) listed the optical device as a 'specie di cannocchiale in cartone a due lenti, con treppiede alla più piccola (che parrebbe l'oculare)' (a type of telescope made of pasteboard with two lenses, with a rather small tripod seeming suitable for only the eyepiece). See the inventory, 16 January 1886, Archivio Storico della Biblioteca Vallicelliana, Roma, binder 5, envelope 3, 17v; reprinted Finocchiaro, *Il Museo*, p. 205. Because of the tripod, the instrument today is correctly catalogued as a microscope in the Museo Astronomico e Copernicano di

Figure 8. Microscope that belonged to Virgilio Spada. Rome, Museo Astronomico e Copernicano di Roma, INAF–Osservatorio Astronomico di Roma. © Astronomical and Copernican Museum of the INAF-Astronomical Observatory of Rome.

youth's telescope in having three draw tubes with raised collars as stops and a reddish colour (now faded); it might have been inspiration to Tornioli (Figure 8).

4. The celestial globe and its purpose

We argued above that the large celestial globe around which the men and women gather serves as a field guide for the youth to make sense of the night sky, just as prints in the publications of Fuchs, Vesalius, Galileo, and Hevelius aided students in gardens, anatomy theatres, or below the night sky (Figure 9). But the globe plays a larger role in the painting, which becomes clearer once we correct mischaracterizations of it by prior art historians.

First, the globe features the constellation of Hercules, not that of Auriga (also known as *Erichtonius*), as previous accounts of the painting have claimed.[59] It must be Hercules because the male nude on the sphere is facing to the left (not right), and he has his feet (not his head) positioned near the northern ecliptic pole (a point at which the great circles of celestial longitude converge, and which is offset from the north celestial pole by 23.5 degrees). Moreover, the male is not shown with a goat as Auriga would be, but with a club in his raised right hand and a lion skin draped over his left arm. These are attributes of Hercules.

Second, we believe that scholars have wrongly equated the globe in the painting with the celestial globe by the Dutch cartographer Willem Janszoon Blaeu,

Roma, INAF–Osservatorio Astronomico di Roma (N.I C133/663 Microscopio). The authors thank Marco Faccini, curator, for providing us with information and photos.

[59] Weston, 'After Galileo', p. 305.

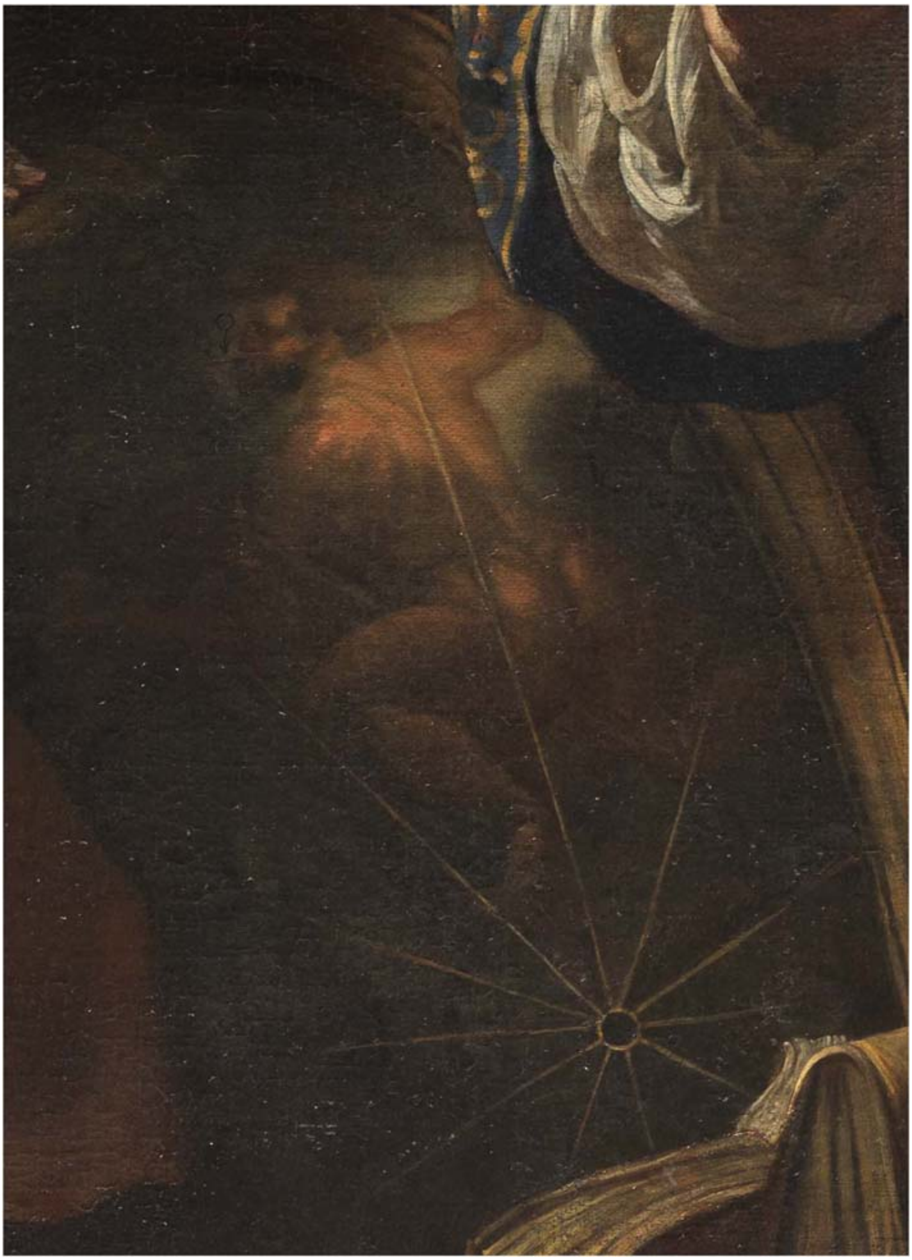


Figure 9. Celestial globe with constellation of Hercules. Tornioli. Detail from *Gli astronomi*. Rome, Galleria Spada.

currently displayed in the Palazzo Spada (Figure 10a and b).[60] The Spada globe is one of a pair of terrestrial and celestial globes with a diameter of 27 in. These were the largest globes made by Blaeu and were unsurpassed in size by any printed

[60]Weston, 'After Galileo', p. 305. Payne, *Telescope and Compass*, pp. 2 and 4.

Figure 10a and b. *On this page*, Willem Janszoon Blaeu. *Celestial Globe*, 1616. *On next page*, detail of Hercules rotated 180°. Rome, Galleria Spada. Marina Cotugno - Juliafoto.it.

globe before 1688.[61] The Spada celestial globe was the first state to be issued and is dated 1616. The terrestrial globe is the fourth state and is dated 1622.[62]

Tornioli's globe is far from a direct copy of Spada's Blaeu globe (see Figures 9 and 10b). It is rendered in colours, whereas the gores of Bernardino's globe were never hand coloured. Tornioli, moreover, has painted the planetary symbols for Mars (♂) and more faintly, Mercury (☿) in front of Hercules's face. These symbols, which do not appear on Bernardino's globe, refer to the astrological characteristics of the bright star *Ras Algethi* (α Herculis) in Hercules's head. *Ras Algethi* in Arabic means 'head of the kneeler' and draws upon the older Greek name for the constellation, *Engonasin*, the Kneeling One.[63] Blaeu

[61]Made by Vincenzo Coronelli (1650–1718), the largest printed globes of the seventeenth century were 42.5 in. in diameter and were first issued in 1688 in Venice. For examples described, see Peter van der Krogt, *Old Globes in the Netherlands* (Utrecht: HES, 1984), Cor L9; Elly Dekker et al., *Globes at Greenwich: A Catalogue of the Globes and Armillary Spheres in the National Maritime Museum, Greenwich* (Oxford: Oxford University Press and the National Maritime Museum, 1999), pp. 316–19; and Sylvia Sumira, *Globes: 400 Years of Exploration, Navigation, and Power* (Chicago: University of Chicago Press, 2014), pp. 90–95.

[62]Tony Campbell, 'A Descriptive Census of Willem Blaeu's Sixty-Eight Centimetre Globes', *Imago Mundi*, 28 (1976), 21–50 (pp. 34 and 36).

[63]All globes and celestial atlases of the Renaissance and later depict at a minimum the 1025 so-called fixed stars catalogued in Ptolemy's *Syntaxis mathematica,* a work better known by its Arabic title, the *Almagest*. Ptolemy's star catalogue was appended to Latin translations of the *Alfonsine Tables*, a thirteenth-century work for calculating the positions of the planets. Starting with the 1524 edition of the *Alfonsine Tables*, the astrological influences of the stars were given in a table, 'Nomina & qualitates stellarum fixarum secumdum Ptol[lemeum]' (Names and qualities of fixed stars according to Ptolemy). See *Alfonsi Hispaniarum Regis Tabule* (Venice 1524), fols. 106r–107v. Much of the information was derived from another work of Ptolemy, the *Tetrabiblos*,

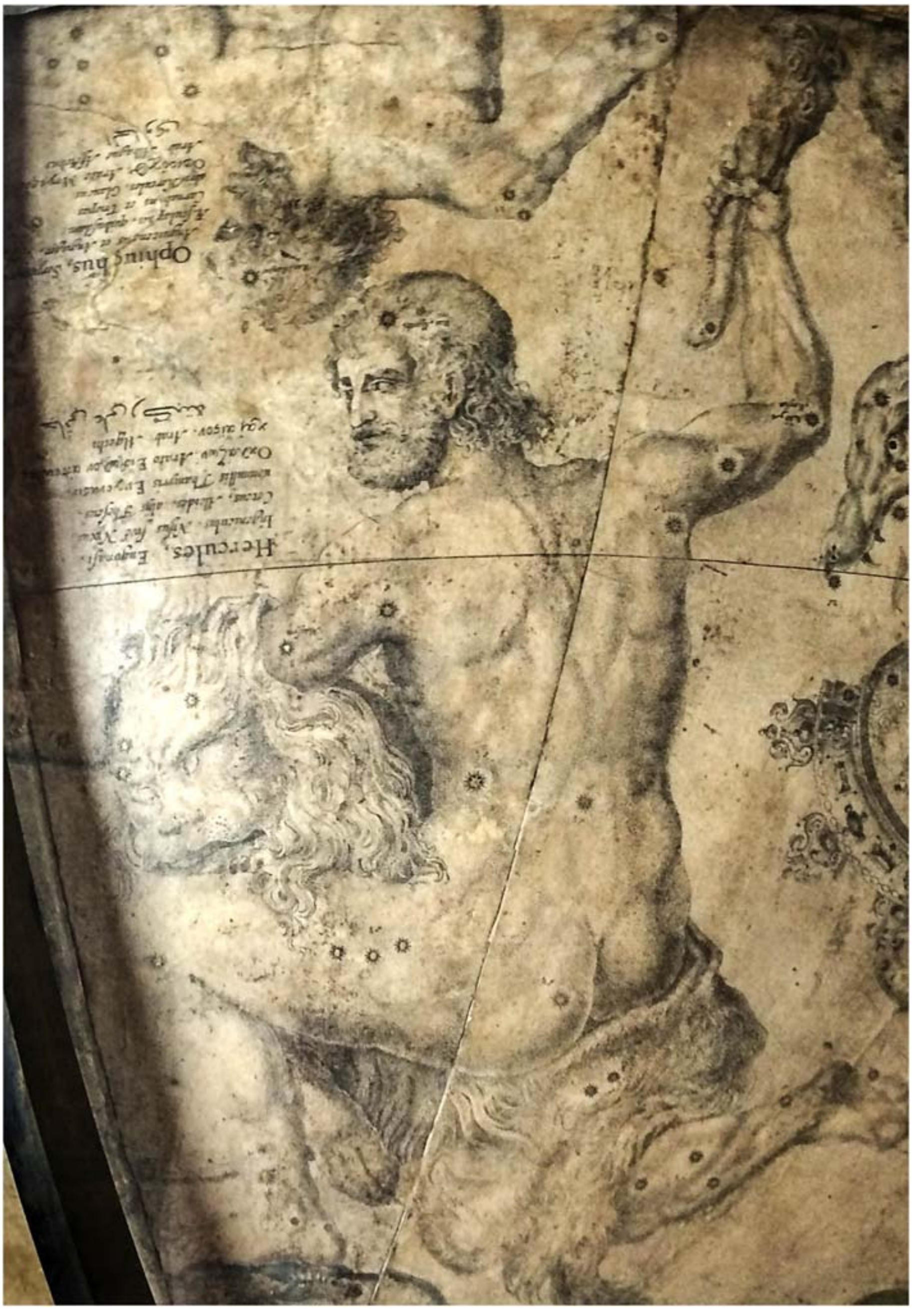


Figure 10 *Continued*

1.9. See Ptolemy, … . *Almagest*, trans. by G. J. Toomer (London: Duckworth, 1984), pp. 339–40; Ptolemy, *Tetrabiblos*, ed. and trans. by F. E. Robbins, Loeb Classical Library (Cambridge, MA: Harvard University Press, 1940, reprint 1980), p. 435; Paul Kunitzsch, 'The Star Catalogue Commonly Appended to the Alfonsine Tables', *Journal for the History of Astronomy*, 17 (1986), 89–98. For an example of a seventeenth-century star catalogue connecting *Ras Algethi* (α Herculis) to Mercury and Mars, see William Ramesey, *Astrologia Restaurata, or, Astrologie Restored* (London, 1654), p. 102.

did denote the star's association with those planets but located the symbols alongside the star amidst the hair on Hercules's head. Another difference is that Blaeu showed Hercules's head in a three-quarter view, whereas Tornioli's is in profile. Lastly, the club wielded by Hercules on the Blaeu globe is in a different position than on Tornioli's globe: Blaeu has the club parallel to Hercules's forearm, whereas Tornioli depicts it parallel to his upper arm.

To find a possible source for Tornioli's depiction, we need to consider the cartography more closely. His globe shows an external perspective of the constellations as viewed from outside the sphere of fixed stars looking down towards the Earth. It is a God's-eye view, rather than the internal perspective of an Earth-bound person looking up at the night sky. It also follows the Hipparchus rule, which dictated that human constellations should be depicted with their figures facing towards the Earth. This was an important astronomical convention because stars were catalogued with names such as 'in the left shoulder'. Swapping proper left and right would cause scientific confusion. Tornioli's Hercules has his back to the viewer because of this convention. He is a classical nude figure with bent knees and is looking towards the left. A lion skin is draped on his outstretched left arm (and may wrap across the front of his body and back over his right thigh, but the painting is not clear enough to tell). He wields a club in his right hand. We cannot resolve what he is holding in his left hand. The figure is spread over several globe gores, which have ecliptic poles. Although Tornioli does not show all the gore lines precisely (as we will describe below), he does take care with the circle of longitude defining the first point of Scorpio. This line crosses the left buttock of Hercules and goes over his right shoulder behind his head. As already mentioned, the astrological influences of the bright star in Hercules's head are conveyed by the use of planetary symbols near his face. The convention of including the planetary natures of stars on globes goes back to the fifteenth century, but cartographers employed different ways of delivering and locating the information on their globes, including text and symbols.[64]

One possible model for Tornioli might have been a 10.4 in. globe made in Rome by Matthaeus Greuter (ca. 1556–1638) in 1626,[65] or an older, 6 in. globe constructed in 1577 in Rome by Mario Cartaro. Virgilio Spada owned an example of the Cartaro globe, and it survives in the Museo Astronomico e Copernicano (Figure 11a and b).[66] Hercules is shown in profile and has his

[64]Elly Dekker, 'Caspar Vopel's Ventures in Sixteenth-Century Celestial Cartography', *Imago Mundi*, 62.2 (2010), pp. 161–90 (p. 8); Dekker et al., *Globes at Greenwich*, pp. 87–91.

[65]Sumira, *Globes*, p. 26. For examples, see Greuter, celestial globe gores, 10.4 in., Rome, 1626, Harvard Map Collection, inv. no. G3160 1626 .N5. Greuter, celestial globe, 19.3 in., Rome, 1636, National Maritime Museum, London, GLB0143 (mounted globe) and GLB0234 (set of globe gores); described in Dekker et al., *Globes at Greenwich*, pp. 347–49, 481–82. Greuter, celestial globe, 19.3 in., Rome, 1636, Istituto e Museo di Storia della Scienza, Florence, inv. no. 2702. https://catalogue.museogalileo.it/object/CelestialGlobe_n01.html.

[66]Mario Cartaro, printed celestial globe, Rome, 1577, 6.14 in., Museo Astronomico e Copernicano di Roma, INAF–Osservatorio Astronomico di Roma, N.I 00040/648; personal communication with Marco Faccini, curator.

Figure 11a and b. *On this page,* Mario Cataro. *Celestial Globe*, 1577. *On next page,* detail of Hercules rotated 180°. Rome, Museo Astronomico e Copernicano di Roma, INAF–Osservatorio Astronomico di Roma, N.I 00040/648. © Astronomical and Copernican Museum of the INAF-Astronomical Observatory of Rome.

Figure 11 *Continued*

club aligned with the upper arm—as in the painting—but Greuter and Cartaro do not note the planetary influences of *Ras Algethi*.

For Tornioli's depiction of Hercules, we must go to a globe in the tradition of Caspar Vopel (1511–61) circa 1536. Vopel was a cartographer and instrument maker from Cologne. His cartography was inspired by the first astronomically rigorous celestial planispheres, which were created by Albrecht Dürer (1471–1528), Conrad Heinfogel (1470–1530) and Johann Stabius (d. 1522), and published in 1515.[67] Like Dürer's planispheres, Vopel's woodcut illustrations in the 1534 Cologne edition of Gaius Julius Hyginus's (64 BCE–17 CE) *Poeticon Astronomicon* (Poetical Astronomy) show the constellations from an external perspective with the stars correctly located. The Hyginus figures served as models for Vopel's printed, 11.4-in. celestial globe, published in 1536 (Figure

[67]Stabius drew the coordinates, Heinfogel located the stars, and Dürer cut the constellation figures. Anna Friedman Herlihy, 'Renaissance Star Chars', in *The History of Cartography III: Cartography in the European Renaissance*, ed. by David Woodward (Chicago: University of Chicago Press, 2007), pp. 99–122 (p. 111). See Susan Dackerman, 'Constellations and Configurations', in *Prints and the Pursuit of Knowledge in Early Modern Europe,* ed. by Dackerman et al. (New Haven: Yale University Press, 2013), pp. 79–124.

12).[68] This globe was notable for marking the planetary influences of stars and including new asterisms; it provided a model for many later celestial globes, including those by Gemma Frisius (1508–55), Louvain (1537),[69] Gerhard Mercator (1512–94), Louvain (1551),[70] and Christoph Schissler (1531–1608), Augsburg (1575).[71] Vopel named *Ras Algethi* on his globe and located the symbols of Mars and Mercury in front of Hercules's face.

While it appears that Tornioli derived his depiction of Hercules from a globe in the tradition of Vopel, many other details make it clear that he did not slavishly copy any particular globe. For starters, he has exaggerated the size of the globe for dramatic effect; it is larger than any commercial globe produced at this date.[72] In addition, Tornioli was sloppy in demarcating the locus where the gores met. He depicted only eleven of the twelve celestial longitude lines that should radiate from it (see Figure 9). Another oddity of Tornioli's globe is his depiction of an open circle at the northern ecliptic pole rather than a point where the lines converge, as was standard in globes produced at this time. He might have confused the point of the ecliptic pole with a wind rose. These had rhumb lines (also known as loxodromes: navigational paths of constant bearing with respect to the magnetic compass) radiating out from them. Wind roses could have open centres, but they only appeared on terrestrial globes and geographical maps. They would be meaningless on a celestial globe or chart.[73] These misrepresentations suggest that Tornioli was not carefully copying from a real globe he had before him, but painting a stylized, representative globe. (Similar conclusions will be reached regarding the astronomical diagrams in *The Astronomers*). Stylized globes were common in art. For instance, allegorical pictures of the Seven Liberal Arts often included generic terrestrial globes with loxodromes. See, for examples, the late-sixteenth-century prints of *Geometria* by Jan Sadeler the Elder (1550–1600) after

[68]See C. Julius Hyginus, *Poeticon Astronomicon* (Venice, 1482), with woodcut illustrations by Vopel; available in the Digitale Sammlungen of the Bayerische Staatsbibliothek, inv. no. urn:nbn:de:bvb:12-bsb00029343-0 (see image 50); https://bildsuche.digitale-sammlungen.de/viewer/templates/viewimage.php?bandnummer=bsb00029343&pimage=00050&v=100 Vopel, printed celestial globe, Cologne, 11.4 in., Kölnisches Stadtmuseum, Cologne, inv. no. KSM 1984–447. Dekker, 'Caspar Vopel's Ventures in Sixteenth-Century Celestial Cartography', pp. 164–68, 179–80.

[69]Frisius (cartography) with engraving by Gerhard Mercator (lettering) and Gaspar van der Heyden (figures), celestial globe, Louvain, 1537, 14.5 in. diameter, National Maritime Museum, London; Elly Dekker and Peter van der Krogt, *Globes from the Western World* (London: Zwemmer, 1993), pp. 33–34.

[70]Dekker and van der Krogt, *Globes from the Western World*, pp. 31, 36–37. Mercator, celestial globe, Louvain, 1551, 16 in. diameter, Harvard Map Collection, inv. no. G3160 1551 .M4. Note that Mercator's illustration of Hercules is very different from Vopel's; Hercules is turning his head to look over his right shoulder.

[71]Schissler, manuscript (engraved) celestial globe, Augsburg, 1575, gilt copper, 16.5 in., Palácio Nacional de Sintra, Sintra, Portugal, inv. no. PNS 3457. See Samuel Gessner, 'The Vopelius–Schissler Connection: Transmission of Knowledge for the Design of Celestial Globes in the 16th Century', *Bulletin of the Scientific Instrument Society*, 104 (2010), 32–42.

[72]Other artists in this period likewise scaled up globes in their works. See, for instance, Hendrick ter Brugghen (1588–1629), *Heraclitus* (with a terrestrial globe), 1628, and *Democritus* (with a celestial globe), 1628, Rijksmuseum, Amsterdam, inv. nos. SK-A-2784 and SK-A-2783; discussed by Kristen Lippincott, 'Globes in Art: Problems of Interpretation and Representation', in *Globes at Greenwich* (1999), pp. 75–86 (pp. 83–84).

[73]Mercator was the first to introduce loxodromes on a terrestrial globe. See Mercator, terrestrial globe, Louvain, 1541, 16 in. diameter, Harvard Map Collection, inv. no. G3170 1541 .M4. Dekker and van der Krogt, *Globes from the Western World*, pp. 34–35. On a small patch of a globe, loxodromes appear the same as they do on portolan charts, but if the lines are followed further along the surface of a globe they will be spirals.

Figure 12. Caspar Vopel. *Celestial Globe*, 1536. Cologne, Kölnisches Stadtmuseum.

Maarten de Vos (1532–1603), or Cornelis Drebbel (1572–1633) after Hendrik Goltzius (1558–1617), or Cornelis Cort (1533–78) after Frans Floris (1519/20–70) (Figure 13).

The globe's focus on Hercules raises questions. As a scientific instrument, a globe should be tipped in its cradle so that the polar axis is parallel to the Earth's axis at the user's latitude.[74] For Rome, that is forty-two degrees using the divisions on the meridian circle as a guide. When the globe is rotated in this position, the stars will rise and set as they do at the user's location. The globe can be used as a star finder to identify bright stars and constellations seen at the time, and to determine the circumpolar stars that will never set at that latitude. It can also be used to solve astronomical problems such as the length of day or night on a given date, where along the horizon a star will rise or set, at what time it will cross the meridian, and what its maximum altitude will be. By tilting the globe to another angle, the user can learn how dissimilar the night sky would

[74]This procedure is known as rectifying the globe and many books of instructions were published in Latin and vernacular languages on how to use a globe to solve astronomical problems. See for example, Ignazio Danti, *Trattato dell'uso della sfera* (Florence, 1573); Robert Hues, *A Learned Treatise of Globes, Both Cœlestiall and Terrestriall: with their severall uses. Written first in Latine, by Mr Robert Hues: and by him so Published. Afterward Illustrated with Notes, by Io. Isa. Pontanus. And now lastly made English, for the Benefit of the Unlearned. By Iohn Chilmead* (London, 1639); and Willem Janszoon Blaeu, *Institutio astronomica de usu globorum & sphærarum cælestium ac terrestrium*, trans. by Martinus Hortensius (Amsterdam, 1640).

Figure 13. Jan Sadeler the Elder after Maarten de Vos. *Geometria*, ca. 1570-1600. New York, Metropolitan Museum. The Elisha Whittelsey Collection, The Elisha Whittelsey Fund, 1949.

look at a different latitude; he or she could find out if the days might be longer or shorter there. Such manipulation of a globe would be an educational exercise, but it is not typically illustrated. In paintings of globes, the artist customarily shows the globe set for use at an angle close to the subject's latitude or to display prominently an area of particular interest to the owner.

For instance, in *The Ambassadors* (1533), Hans Holbein the Younger (1497–1543) shows two globes between Jean de Dinteville (1504–55), seigneur de Polisy and ambassador of the King of France, and his friend, Georges de Selve (1508–41), bishop of Lavaur, who were in London (Figure 14). The terrestrial globe is turned so that Paris, Rome, and de Dinteville's home town are easily read. The celestial globe is set for use in Rome and features constellations with Gallic associations. Holbein has apparently oriented the globes to symbolize the French diplomats' mission to bring Henry VIII (r. 1509–47) back into alliance with the pope.[75] Two other well-known examples in which globes have iconic significance are the so-called 'Armada Portrait' of Elizabeth I (r. 1558–1603), painted around 1588, and the portrait of Sir Francis Drake (d. 1596), attributed to Marcus Gheeraerts the Younger (1561–1636) and painted in 1591. In the former, Elizabeth lays claim to North America by placing her hand on that section of a terrestrial globe.[76] In the latter, a terrestrial globe commemorates Drake's circumnavigation of the world, by featuring his passage from the west coast of Africa across the Atlantic Ocean to 'Brasilia'.[77]

In other artworks, a globe is an attribute of a profession such as a geographer or astronomer, or it symbolizes the known earth and the cosmos. In such cases, European artists typically showed Europe and the north Atlantic or recognizable northern constellations such as Ursa Major. Take for instance, the depiction of *Astronomia* (post 1575) by Jan Sadeler the Elder after Maarten de Vos, Bernardo Strozzi's (1581–1644) *Eratosthenes Teaching in Alexandria* (ca. 1635), or Jan Vermeer's (1632–75) *The Astronomer* (ca. 1668) (Figure 15).[78]

Thus, we would expect Tornioli to depict a globe set up for use in Rome. Instead he shows us a globe set for a user near the equator. He has put the north celestial pole near or below the horizon. This enables him to feature the constellation of Hercules in an upright position for the benefit of the painting's viewers. Had he set the globe for Rome's latitude, Hercules would have been upside down and more foreshortened near the top. Why did Tornioli take pains to show this constellation?

[75]Elly Dekker and Kristen Lippincott, 'The Scientific Instruments in Holbein's Ambassadors: A Re-Examination', *Journal of the Warburg and Courtauld Institutes*, 62 (1999), 93–125 (pp. 93–106). See John North, *The Ambassadors' Secret: Holbein and the World of the Renaissance* (London: Hambledon & London, 2002), pp. 107–18, 153–57, 296–99, who mistakenly argues that the celestial globe is set for London. The meridian ring is tipped so that the angle between the north celestial pole and the horizon ring is 42 degrees, which is the proper globe setting for Rome. Had someone incorrectly set the globe by means of the complementary angle from the celestial equator to the horizon ring, that angle would be 48 degrees. It would serve the latitude of Paris, but not London, which was recorded as 51 to 52 degrees in contemporary sources.

[76]English, formerly attributed to George Gower, *Elizabeth I* ('The Armada Portrait'), ca. 1588, Woburn Abbey, England.

[77]Attributed to Marcus Gheeraerts, *Sir Francis Drake*, 1591, National Maritime Museum, Greenwich, England, inv. no. BHC2662. Lippincott, 'Globes in Art', pp. 76–78.

[78]*Astronomia* from the series, *The Seven Liberal Arts* by Jan Sadeler I after Maarten de Vos, engraving, after 1575, Harvard Art Museums, inv. no. R4919; Bernardo Strozzi, *Eratosthenes Teaching in Alexandria*, ca. 1635, Musée des beaux-arts de Montréal, inv. no. 1959.1225c. Lippincott, 'Globes in Art', pp. 76–77, 82–83.

Figure 14. Hans Holbein the Younger. *The Ambassadors*, 1533. London, National Gallery. © National Gallery, London / Art Resource, NY.

Perhaps because Hercules was viewed as an intellectual and a paragon of the astronomer in the early modern period. Atlas was described as the most ancient teacher of astronomy, and Hercules his most accomplished student. On frontispieces and illustrated title pages of seventeenth-century astronomical texts—such as those by Johannes Bayer and Andrea Argoli—they are shown together carrying the burden of the celestial sphere for Urania's ministrations or supporting an edifice that reads, 'Let no one enter here who is ignorant of geometry' (in Greek)—the inscription supposedly written over the entrance to Plato's academy (Figure 16).[79]

The Astronomers does not contain the only representation of a globe attributed to Tornioli. He also visualized the celestial sphere in designs that were

[79]For example, Bayer, *Uranometria*, title page; Andrea Argoli, *Ephemerides* (Venice, 1638), title page; Argoli, *Ephemerides exactissimae caelestium motuum* (Lyon, 1659), frontispiece. See Söderlund, 'Inspiration from Antique Heroic Deeds: Hercules as an Astronomer', *Culture and Cosmos*, 16.1 and 2 (2012), 139-150; Söderlund, *Taking Possession of Astronomy*, pp. 248–249, 298–301.

Figure 15. Johannes Vermeer. *The Astronomer*, 1668. Paris, Musée du Louvre. © RMN-Grand Palais / Art Resource, NY.

engraved by Luca Ciamberlano (1580–1641) for Luigi Manzini's *Applausi Festivi* (Festive Applause, 1637) (Figure 17). The engravings show Tornioli's inventions for ephemeral, pyrotechnical machines created to celebrate the election of Ferdinand III (1608–1657) as Holy Roman Emperor and patronized by Cardinal Maurizio of Savoy (1593–1657).[80] In *Triumph of the Imperial Eagle over the Ottoman moon*, Tornioli situates a celestial sphere at the top centre of the image. The spectator's view is centred on the north ecliptic pole and the constellation of Draco. Other prominent northern constellations are loosely placed around Draco in approximate locations. This representation is similar to that of the central portion of an ecliptic-polar-external projection

[80]Weston, *Tornioli*, pp. 59–62.

Figure 16. Hercules as the most accomplished astronomical student of Atlas. Johannes Bayer. *Uranometria*, Augsburg, 1603. Houghton Library, Harvard University. Typ 620.03 196.

planisphere, which has been rotated so that the first points of Aries and Libra are respectively at the 12 and 6 o'clock positions, with Cancer and Capricorn at 9 and 3. This unusual rotation maximizes the number of constellations seen in an upright position rather than upside down as they would appear on a

Figure 17. Luca Ciamberlano after Niccolò Tornioli, *Triumph of the Imperial Eagle over the Ottoman moon*, engraving in Luigi Manzini, *Applausi Festivi* (Rome: Pietro Antonio Facciotti, 1637), p. 70. National Gallery of Art Library, David K. E. Bruce Fund.

normally-mounted, oblique celestial globe.[81] Prominent among them is Hercules. The zodiac and the Sun's path are along the vertical edge of the sphere and cannot be seen directly from the spectator's vantage point; however, their glory is indicated by streams of fireworks shooting forth, obscuring the crescent moon alongside. This celestial sphere, which has not been considered previously in relation to *The Astronomers*, signals Tornioli's prior investment in this scientific instrument, his atypical orientation of it to emphasize constellations such as Hercules, and his cartographic imprecision.

5. Astronomical diagrams

As noted earlier, scholars have identified the elderly figure on the left of *The Astronomers* as Aristotle, thinking that the open page in the book he holds is an Aristotelian model of the universe (Figure 18).[82] In fact, the image does not show the concentric spheres of his cosmos but a Ptolemaic diagram of the Sun's motion taken from a Paris or Wittenberg edition of Georg von Peuerbach's *Theoricae novae planetarum* (New Theorics of the Planets), an example of which was in Bernardino Spada's library (Figure 19).[83] The diagram shows the Sun travelling around the Earth along a circular path eccentric to it. It moves at a uniform angular speed in relation to an imaginary mathematical point called the equant, which is offset from both the centre of the Earth and the centre of the Sun's orbit. This diagram shows planetary motions that are not visible through nor deducible from a single observation with or without a telescope. Even though the diagram held by the elderly figure is not an Aristotelian model, at least one work by Aristotle features in the painting: the inscription 'ARIST' on the binding of one of the five tomes heaped in a pile in the foreground makes clear that this book contains his writings (Figure 20).

The mathematical sketch on the long sheet of paper, appears to be a gesture to a Ptolemaic diagram of a geometric device used to explain the forward and retrograde motions of a planet in orbit around the Earth (Figure 21). The device consists of a deferent (a large circle eccentric to the Earth) along which moves the empty mathematical centre of an epicycle, a smaller circle around which the

[81] Going counter-clockwise from the top in the order of the zodiacal signs, these include Pegasus, Cepheus, Andromeda, Cassiopeia, Hercules, and Cygnus. The earliest published ecliptic polar planisphere oriented like Tornioli's with the equinoctial ecliptic colure running vertically and the solstitial running horizontally appeared inset on wall maps by Petrus Plancius in 1592 and 1594, but it lacks Cassiopeia, Hercules, and Cygnus. See Petrus Plancius, *Orbis terrarium typus de integro multis in locis emendatus* (Amsterdam, 1594). For a planisphere with both the same orientation and constellations, see the inset to the great wall map of Joan Blaeu, *Nova totius terrarum orbis tabula* (Amsterdam, 1648). Deborah J. Warner, *The Sky Explored: 1520–1800* (Amsterdam: Theatrum Orbis Terrarum Ltd, 1979), pp. 26–27, 202.

[82] Weston, 'After Galileo', p. 304.

[83] ASR, Notai Tribunali A. C., vol. 5933, fol. 768v. Bernardino had the 1558 edition of *Theoricae novae planetarum Georgii Purbachii, … ab Erasmo Reinholdo, … pluribus figuris auctae, et illustratae scholiis* (New Theorics of the Planets by Georg von Peuerbach with Commentary and Figures Added by Erasmus Reinhold) published in Paris by Charles Périer but the same woodcut diagram appears in editions published in Paris by Chrétien Wechel (1543, 1550) and Périer (1553, 1555, 1556, 1557, 1558) and in Wittenberg by Hans Lufft (1542, 1553) and Hans Lufft and Johann Krafft (1580).

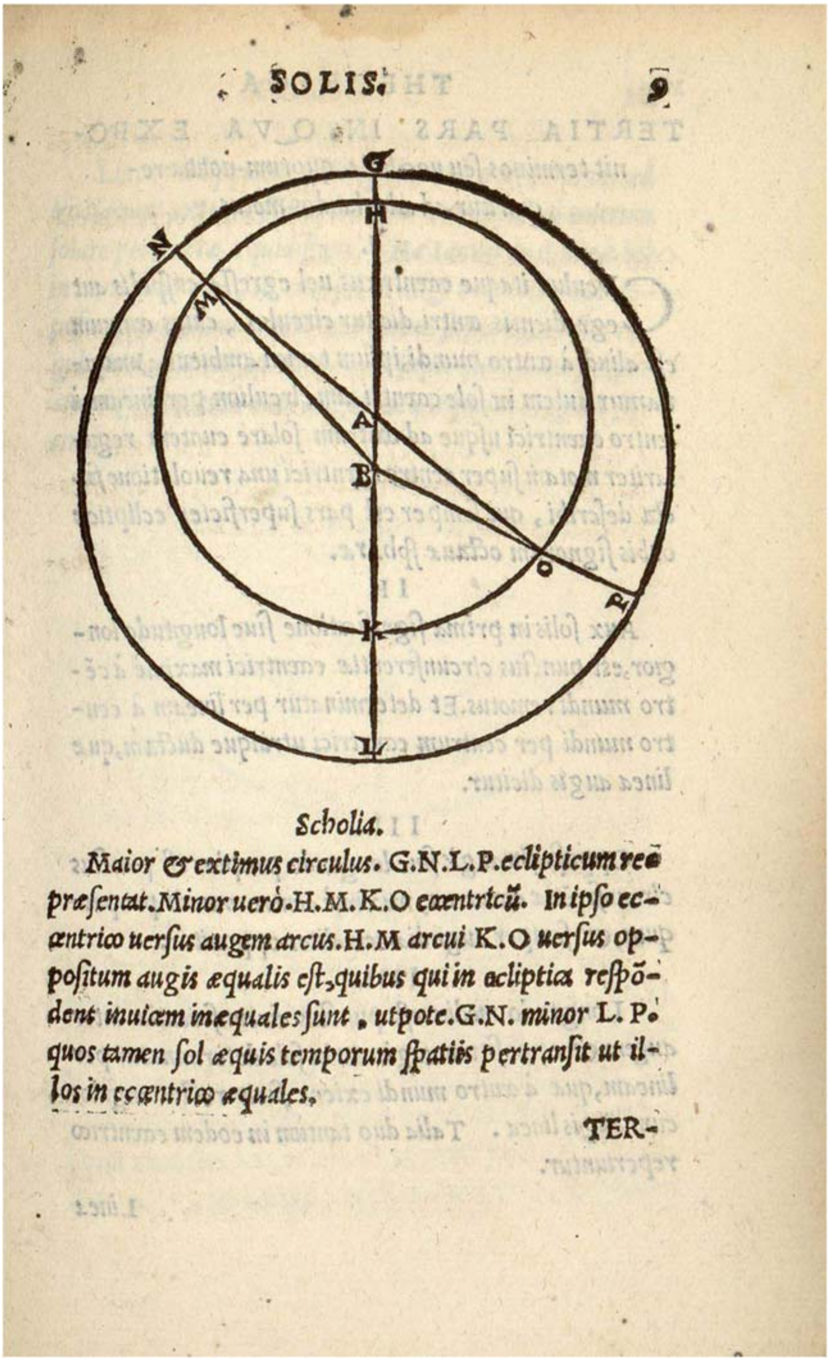
Figure 18. Open page in volume held by the Old Astronomer. Tornioli. Detail from *Gli astronomi*. Rome, Galleria Spada.

planet travels. Figure 22 shows such a model in Peuerbach's book. In the painting, however (see Figure 21), the centre of the epicycle has a subtly shaded self-luminous body that casts light (indicated through shading) onto the facing sides of each of three bodies on its ring, thereby illustrating how a single satellite circling a sun would exhibit phases if seen by a person at a distant vantage point. Five other circles form a grid of nine with these four and float meaninglessly in space around the two large interlocked circles.

On the one hand, it is surprising that the second diagram features meaningless details since Tornioli was so intent on putting both diagrams into his painting that he neglected to follow the contours and perspective of the warped papers on which they were printed and drawn. On the other hand, the incoherence of the diagram is consistent with the errors in the technicalities noted on the celestial globe: we see the artist doing his best to render astronomical theories and instruments he does not fully understand. Tornioli's mistakes accentuate the challenges inherent to observing and understanding astronomy.

6. The celestial phenomena

The final detail that we will consider–the celestial phenomena in the painting's upper right corner–is puzzling and open to interpretation. Tornioli shows us two celestial spheres sitting on a cloud shelf to which the New Astronomer



SOLIS. 9

Scholia.

Maior & extimus circulus. G.N.L.P. eclipticum repræsentat. Minor uerò. H.M.K.O eccentricū. In ipso eccentrico uersus augem arcus. H.M arcui K.O uersus oppositum augis æqualis est, quibus qui in ecliptica respōdent inuicem inæquales sunt, utpote. G.N. minor L.P. quos tamen sol æquis temporum spatiis pertransit ut illos in eccentrico æquales.

TER-

Figure 19. Ptolemaic diagram of the Sun's orbit (represented by eccentric circle *HMKO*) around the Earth (*B*) fixed in the centre of the cosmos. Georg von Peuerbach, *Theoricæ novæ planetarum Georgii Purbachii fœliter incipiunt. Figura novem sphærarum & elementorum ordinem designans*, NuBIS, accessed 24 juin 2021, https://nubis.univ-paris1.fr/ark:/15733/45v4, cliché Bibliothèque de la Sorbonne.

Figure 20. Book spine. Detail from Tornioli, *Gli astronomi*. Rome, Galleria Spada.

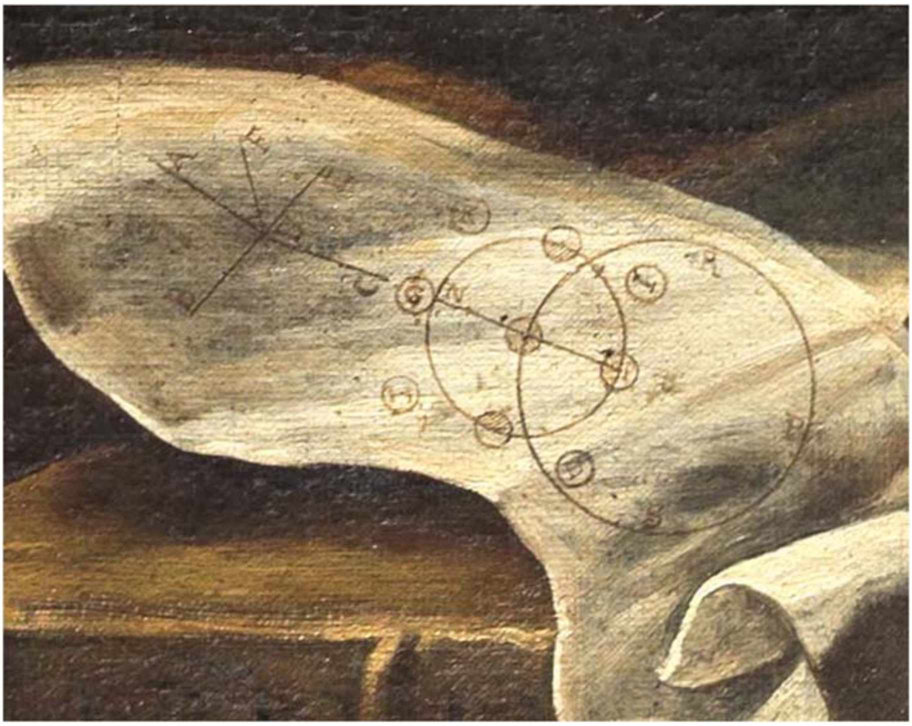
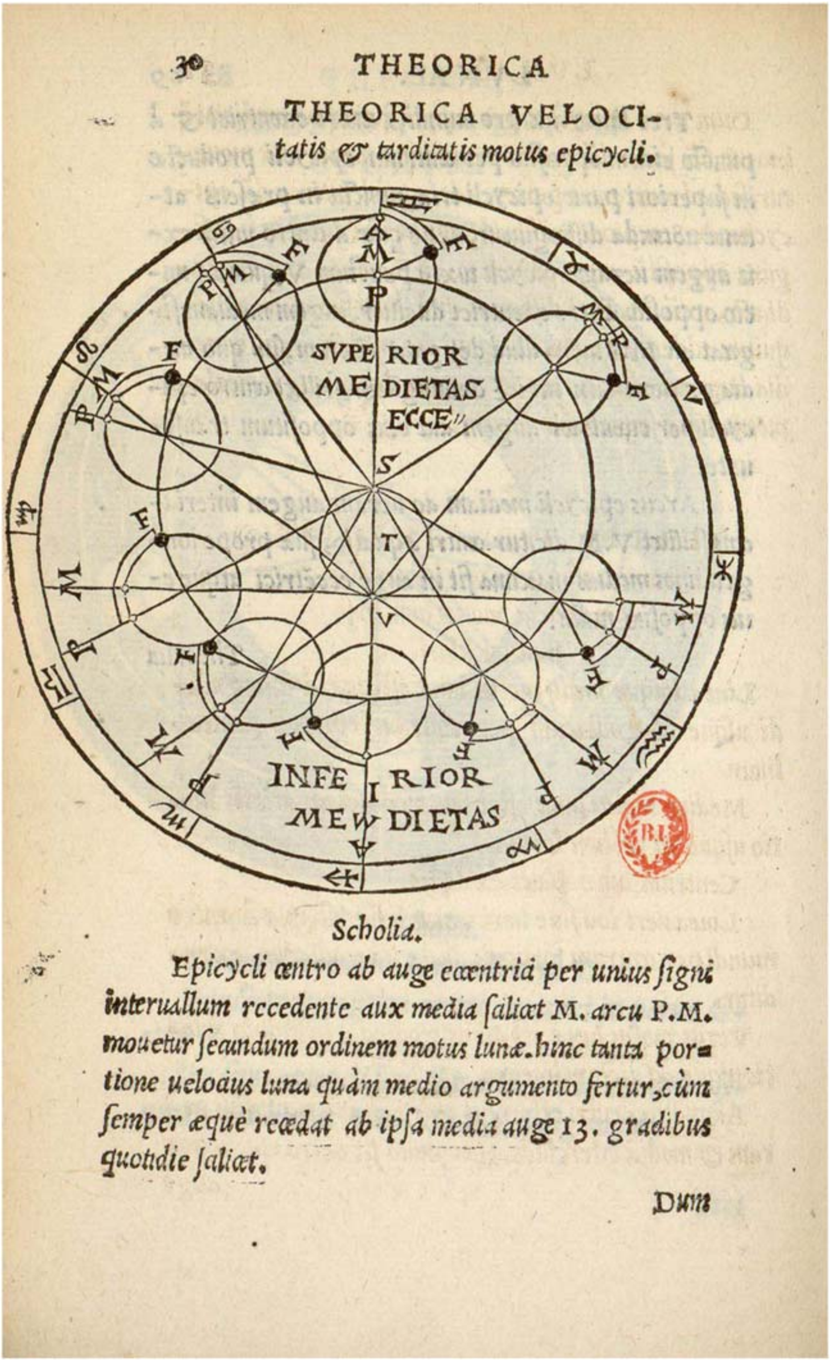


Figure 21. Diagram on long folio of paper. Tornioli. Detail from *Gli astronomi*. Rome, Galleria Spada.

points (Figure 23). Art historians have characterized the heavenly sight as the phases of the Moon.[84] It is true that Galileo made controversial discoveries about the Moon, which were worthy of the New Astronomer's attention. Contrary to Aristotelian philosophy, he saw through his telescope that the Moon was not a smooth, perfect sphere whose spots were due to differences in density. The Moon was mountainous and craggy like the Earth, with bright patches illuminated by sunlight and dark ones in shadow. Visual evidence of earthshine on the Moon, moreover, indicated that the Earth was moonlike

[84]For this interpretation of the celestial phenomena, see Weston, *Niccolò Tornioli*, p. 125; Cannatà, *Galleria di Palazzo Spada*, p. 82; Cannatà, 'Nicolò Tornioli', p. 177; Vicini, 'Cat. n. 153', p. 388; and Payne, *Telescope and Compass*, p. 1.


30 THEORICA

THEORICA VELOCI-
tatis & tarditatis motus epicycli.

Scholia.

Epicycli centro ab auge eccentrici per unius ſigni interuallum recedente aux media ſaliat M. arcu P.M. mouetur ſecundum ordinem motus lunæ. hinc tanta portione uelocius luna quàm medio argumento fertur, cùm ſemper æquè recedat ab ipſa media auge 13. gradibus quotidie ſaliat.

Dum

Figure 22. Typical Ptolemaic diagram of epicycles, which Tornioli may have been trying to represent on the folio. The Earth (*T*) is fixed in the centre of the cosmic sphere, shown by the outer circle divided into the signs of the Zodiac. A planet (*F*) orbits the Earth on a complicated path determined by its motion around an epicycle (here illustrated in nine positions) that travels along a deferent circle (whose centre is *S*) at a constant rate with respect to the equant point (*V*). Georg von Peuerbach, *Theoricae novae planetarum*, Paris, 1543. Cliché Bibliothèque de la Sorbonne.

Figure 23. Celestial phenomena. Tornioli. Detail from *Gli astronomi*. Rome, Galleria Spada.

insofar as it too reflected sunlight.[85] These were significant discoveries that Galileo announced in early 1610 in the *Sidereus nuncius* (a book in Bernardino's library), but to us neither sphere in the painting resembles the Moon in any of its phases as it waxes and wanes; in particular, the horns of the lunar crescent never wrap around three quarters of the Moon's disk as it does in the left sphere.

Just as the figures in the painting are at best generic, representing old and new generations rather than specific individuals, it is not possible to identify the two naturalistically rendered spheres at the top right of the painting with specific discoveries. To our eyes, the spheres appear deliberately obscured, which in turn could be a commentary on the difficulty of observing through a telescope or the difficulty of observing because of inclement weather, atmospheric refractions, or other phenomena. If pushed to make a more precise identification, we would speculate that this depiction might be meant to signify Venus in its crescent phase on the left (which Galileo had observed with his telescope in the winter of 1610–11) and the Sun with its spots on the right (which Galileo first observed in late 1610)—both magnified as they would be when observed through a telescope.

We acknowledge that the horns of the crescent extend too far for phases of Venus, but the artist may never have seen Venus in this state, whereas he has certainly seen the Moon and would have known better. The alternative that

[85]Galilei, *Sidereus nuncius* (Venice, 1610); Galilei, *Sidereus Nuncius, or the Sidereal Messenger*, trans. by Albert Van Helden (Chicago: University of Chicago Press, 1989), pp. 9–12, 39–57. All references to the *Sidereus nuncius* will be to this annotated edition from 1989. Roger Ariew, 'Galileo's Lunar Observations in the Context of Medieval Lunar Theory', *Studies in History and Philosophy of Science*, 15 (1984), 213–26.

the image shows an eclipse is unsatisfactory because there is no place in the seventeenth-century cosmos where one could see the shadow of a small body fall on a larger sunlit body with these relative proportions. We also recognize that sunspots are not visible at night when the Sun is below the horizon but reiterate that this section of the painting is far from realistic; above all else, we argue that these details are obscured and difficult to decipher. We consider the two spheres to be akin to two diagrams depicted on the same plate in an astronomy book or on the edges of a large chart, as was very common in the period.

The discoveries concerning Venus and the sunspots were both remarkable and their interpretation controversial, as numerous astronomical texts in the Spada libraries attest. The phases of Venus could only be witnessed through a telescope and were the subject of partisan debate. Galileo excitedly spread the news in letters to astronomers on both sides, including Kepler and Christopher Clavius, S.J. (1538–1612).[86] For Galileo, they indicated that Venus shone by reflected light from the Sun just as the Moon and Earth did. This was a non-starter for Aristotelians such as Ulisse Albergotti, Giuseppe Biancani, and Fortunio Liceti, whose books were in Bernardino Spada's library and attacked Galileo on this point.[87] They maintained that the celestial realm was utterly different in substance to the sublunary realm. The heavenly bodies were self-luminous; the Earth dark.[88] Other adherents to the Aristotelian-Ptolemaic system had since the Middle Ages accepted that the planets and fixed stars received light from the Sun.[89] For them, the problem was not the discovery of phases of Venus, but their sequence, size, and shape.[90] The observed phases indicated that Venus revolved around the Sun and not around the fixed Earth in accordance with tradition, nor was Venus moving around its Ptolemaic epicycle travelling along a large circle eccentric to the Earth and either 'above' or 'below'

[86]Galileo to Kepler through Giuliano de' Medici (1453–78), Tuscan ambassador in Prague, 11 December 1610 and 1 January 1611, in Galilei, *Le Opere*, X, p. 483, XI, pp. 11–12; first published in Johannes Kepler, *Dioptrice seu demonstratio eorum quae visui & visibilibus propter conspicilla non ita pridem inventa accidunt* (Augsburg, 1611), pp. 18–20; see Kepler, *Gesammelte Werke*, ed. by Max Caspar et al., 26 vols. (Munich: C.H. Beck, 1937–2017), IV, pp. 346–348. Galileo to Christopher Clavius, 30 December 1610, in Galilei, *Le Opere,* X, p. 500. Translations in Stillman Drake, 'Galileo, Kepler, and Phases of Venus', *Journal for the History of Astronomy*, 15 (1984), 198–208 (pp. 201–02). Paolo Palmieri, 'Galileo and the Discovery of the Phases of Venus', *Journal for the History of Astronomy*, 32.107 (2001), 107–29 (pp. 109-110).

[87]See Ulisse Albergotti, *Dialogo di Fr. Ulisse Albergotti … nel quale si tiene contro l'opinione commune de gli astrologi, matematici e filosofi, la Luna esser da se luminosa e non ricevere il lume dal sole, ne che gl'eclissi di lei si causino dall'interpositione della Terra fra questi doi luminarii* (Viterbo, 1613); Giuseppe Biancani, *Sphaera mundi* (Bologna, 1620); and Fortunio Liceti, *De novis astris, et cometis* (Venice, 1623); in Bernardino's library, ASR, Notai Tribunali A. C., vol. 5933, fols. 763r–763v.

[88]Aristotle, *On the Heavens*, trans. by K. C. Guthrie, Loeb Classical Library (Cambridge, MA: Harvard University Press, 1939); Aristotle, *Physics*, trans. by P. H. Wicksteed and F. M. Cornford, Loeb Classical Library, 2 vols. (Cambridge, MA: Harvard University Press, 1934–57). Galileo reviewed these arguments of Aristotle in Galilei, *Dialogo*; Galilei, *Dialogue Concerning the Two Chief World Systems—Ptolemaic and Copernican*, trans. by Stillman Drake (Berkeley: University of California Press, 1967), see the First Day, pp. 9–105.

[89]These philosophers drew upon the *Liber de Elementis* of pseudo-Aristotle. Roger Ariew, 'The Phases of Venus before 1610', *Studies in History and Philosophy of Science*, 18.1 (1987), 81–92; Bernard R. Goldstein, 'The Pre-telescopic Treatment of the Phases and Apparent Size of Venus', *Journal for the History of Astronomy*, 27 (1996), 1–12.

[90]Palmieri, 'Galileo and the Discovery of the Phases of Venus', pp. 115, 118–20.

the Sun in the order of celestial spheres.[91] As Galileo put it to Kepler in December 1610, Venus 'draws in train the decision of great controversies in astronomy, and in particular contains in itself a strong argument for the Pythagorean and Copernican arrangement'.[92] In 1623 in *Il Saggiatore*, another book in Bernardino Spada's library, Galileo reinforced this point in a print showing the phases of Venus alongside the telescopic appearances of Saturn, Jupiter, and Mars (Figure 24).[93] The print was a guide to observers and readers of the text. Galileo claimed that the telescope showed the true shapes and sizes of the planets during the course of their orbits as witnessed from the Earth. These apparent changes in diameter and shape challenged the traditional Aristotelian-Ptolemaic order.

A bigger blow to tradition was struck by Galileo's observations of Jupiter in January 1610. Through his telescope he saw four satellites orbiting the planet. No philosopher ancient or modern had ever known of their existence. Their presence countered two criticisms of the Copernican theory: If the Earth were a planet, why was it the only one to have a moon? And if the Earth orbited the Sun, how could it keep the Moon revolving around it and not leave it behind? The answer to this last question could not be solved by Aristotelian physics, but the existence of Jupiter's moons revealed that more than one centre of circular motion was possible in the cosmos. Galileo rushed news of his finding into print in mid-March 1610 in his *Sidereus nuncius* (which was in Bernardino's library).[94] The epic nature of the discovery at first led us to think that the right-hand sphere in Tornioli's painting might depict Jupiter with its four moons represented as little spheres carried around the central body by a ghostly Jovian atmosphere.[95] However, while all on the same plane, the moons could not be seen in front of Jupiter's disk and were always depicted far extended from its surface on either side.

A slightly more plausible interpretation of the right-hand sphere is a depiction of sunspots migrating across the Sun. Galileo first observed sunspots with his telescope in late 1610 and showed them off to friends in Rome in May 1611. In March or April 1611, the Jesuit Christoph Scheiner also observed sunspots and in October began to record their positions. In January 1612, he anonymously published *Tres epistolae de maculis solaribus scriptae ad Marcum Welserum* (Three Letters on Solar Spots written to Marc Welser). Consistent with the Aristotelian view of heavenly perfection, he did not believe that spots could

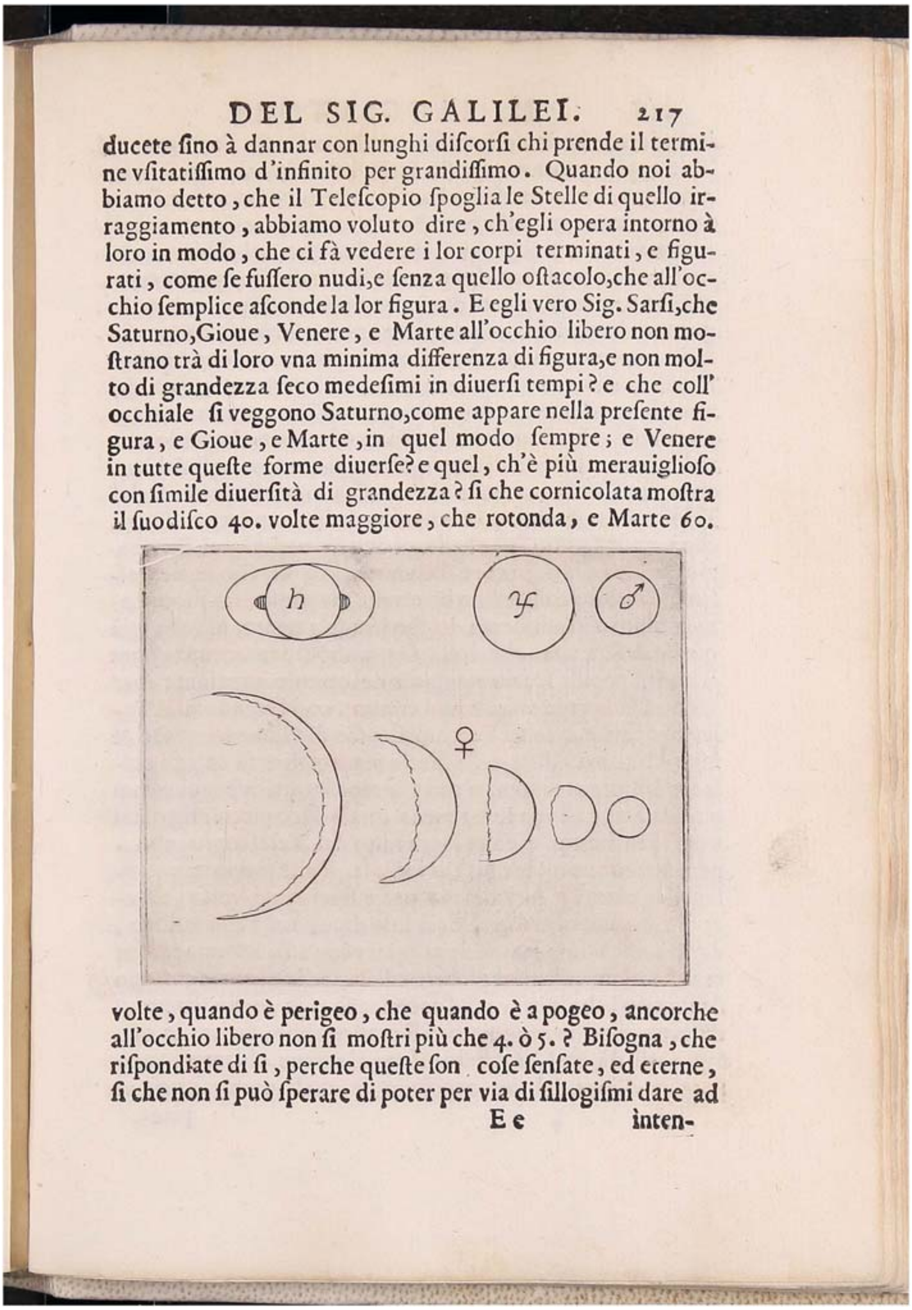
[91] Owen Gingerich, 'Phases of Venus in 1610', *Journal for the History of Astronomy*, 15 (1984), 209–10; Palmieri, 'Galileo and the Discovery of the Phases of Venus'.

[92] Galileo to Kepler, 11 December 1610; translation from Drake, 'Galileo, Kepler, and Phases of Venus', pp. 201-02.

[93] Galileo, *Il Saggiatore* (Rome, 1623), p. 217. Weston, 'Universal Knowledge and Self-Fashioning'. ASR, Notai Tribunali, A. C. vol. 5933, fol. 765r.

[94] The solution to the conundrum of a moving Earth required the development of a new physics in the seventeenth century to replace the old. Kepler, Galileo, Descartes (1596–1650), Huygens (1629–95), and Newton (1643–1727) all contributed to it. For discussion of Jupiter's moons and their significance, see Galilei, *Sidereus Nuncius, or the Sidereal Messenger*, pp. 15–17, 64–86. ASR, Notai Tribunali, A. C. vol. 5933, fol. 769r.

[95] Galileo makes this case for a vaporous orb of aether around Jupiter on the last page of the *Sidereus nuncius*. See Galilei, *Sidereus nuncius*, p. 29.



DEL SIG. GALILEI. 217

ducete ſino à dannar con lunghi diſcorſi chi prende il termine vſitatiſſimo d'infinito per grandiſſimo. Quando noi abbiamo detto, che il Teleſcopio ſpoglia le Stelle di quello irraggiamento, abbiamo voluto dire, ch'egli opera intorno à loro in modo, che ci fà vedere i lor corpi terminati, e figurati, come ſe fuſſero nudi, e ſenza quello oſtacolo, che all'occhio ſemplice aſconde la lor figura. E egli vero Sig. Sarſi, che Saturno, Gioue, Venere, e Marte all'occhio libero non moſtrano trà di loro vna minima differenza di figura, e non molto di grandezza ſeco medeſimi in diuerſi tempi? e che coll' occhiale ſi veggono Saturno, come appare nella preſente figura, e Gioue, e Marte, in quel modo ſempre; e Venere in tutte queſte forme diuerſe? e quel, ch'è più merauiglioſo con ſimile diuerſità di grandezza? ſi che cornicolata moſtra il ſuo diſco 40. volte maggiore, che rotonda, e Marte 60. volte, quando è perigeo, che quando è apogeo, ancorche all'occhio libero non ſi moſtri più che 4. ò 5.? Biſogna, che riſpondiate di ſi, perche queſte ſon coſe ſenſate, ed eterne, ſi che non ſi può ſperare di poter per via di ſillogiſmi dare ad

E e inten-

Figure 24. Galileo Galilei. *Il Saggiatore*, Rome, 1623. Florence, Biblioteca Nazionale Centrale.

sully the face of the Sun. Instead he proposed that the spots were satellites encircling the Sun. After Galileo received a copy of Scheiner's publication from Welser, asking for comment, he resumed his observations in the spring of 1612 and replied in three letters of his own. Galileo showed that the spots were indeed on the Sun's surface, they changed in size over time, and their motion across the Sun's face was evidence that the Sun rotated. His landmark tract of 1613, *Istoria e Dimostrazioni intorno alle Macchie Solari e loro Accidenti*, which was held in Bernardino Spada's library, contained daily illustrations of the spots' progressions, which can be assembled together like a modern flipbook.[96] By 1630 Scheiner agreed with Galileo that the Sun was not perfect and that the Aristotelian-Ptolemaic system was flawed. He, moreover, pioneered a new way to illustrate the motions of the spots across the Sun in his *Rosa Ursina* (1630).[97] Although this book was not in Bernardino or Virgilio's libraries, Bernardino owned a work by another Jesuit, Charles Malapert, with similar plates (Figure 25).[98] Such an illustration may have been Tornioli's inspiration for the celestial figure on the right in *The Astronomers*, insofar as the sequence of splotches across the right sphere recalls how Scheiner, Malapert, and others recorded the diachronic path of sunspots. The philosophical debate between Galileo and Scheiner on the nature of sunspots relied heavily on visual illustrations in training the eye and mind to witness nature correctly.

Although the New Astronomer gestures to the spheres we think may stand for Venus and the Sun, we must emphasize that the naked eye would never offer such details. Without a telescope, the planets would appear as bright stars wandering against the background of fixed stars, and even with a telescope, a contemporary observer would see the planets merely as tiny disks (or in the case of Venus, sometimes a faint crescent, or Saturn, an oblong shape) while the stars were points of light. To get a sense of what Galileo and his contemporaries could see through a telescope, consider photographs of planets (Figures 26 and 27) created through modern telescopes of similar powers to those of Galileo's day, and imagine the view to be unstable, ringed with blurry coloured fringes, and so narrow a field that only one planet could be watched at a time. The point of these photographs is to emphasize how much imagination and interpretation is painted into Tornioli's *Astronomers*. The phenomena to which the New Astronomer points are in fact highly artificial if our hypotheses are correct. Perhaps the artist thought that seventeenth-century viewers could understand the celestial figures better than mathematical diagrams, being seemingly more natural than abstract. The painting thereby could help spectators train their sight through its own imagery and through their own civil conversations about the canvas.

The controversies surrounding Venus and sunspots were excellent starting points for civil conversation. They showed cracks in the Aristotelian-Ptolemaic system but did not prove that the Earth was a moving planet. One could readily

[96]ASR, Notai Tribunali, A. C. vol. 5933, fol.765r. Weston, 'Universal Knowledge and Self-Fashioning'.

[97]Galileo Galilei and Christoph Scheiner, *On Sunspots*, trans. by Eileen Reeves and Albert Van Helden (Chicago: University of Chicago Press, 2010); Scheiner, *Tres epistolae de maculis solaribus, scriptæ ad Marcum Welserum* (Augsburg, 1612); Galilei, *Istoria e dimostrazioni intorno alle macchie solari e loro accidenti* (Rome, 1613); Galilei, *Discoveries and Opinions of … ,*. trans. by Stillman Drake (Garden City, NY: Doubleday, 1957), pp. 87–144: 'Letters on Sunspots'.

[98]Charles Malapert, *Austriaca sidera heliocyclia, astronomicis hypothesibus illigata* (Douai, France, 1633); ASR, Notai Tribunali A. C., vol. 5933, fol. 765r.

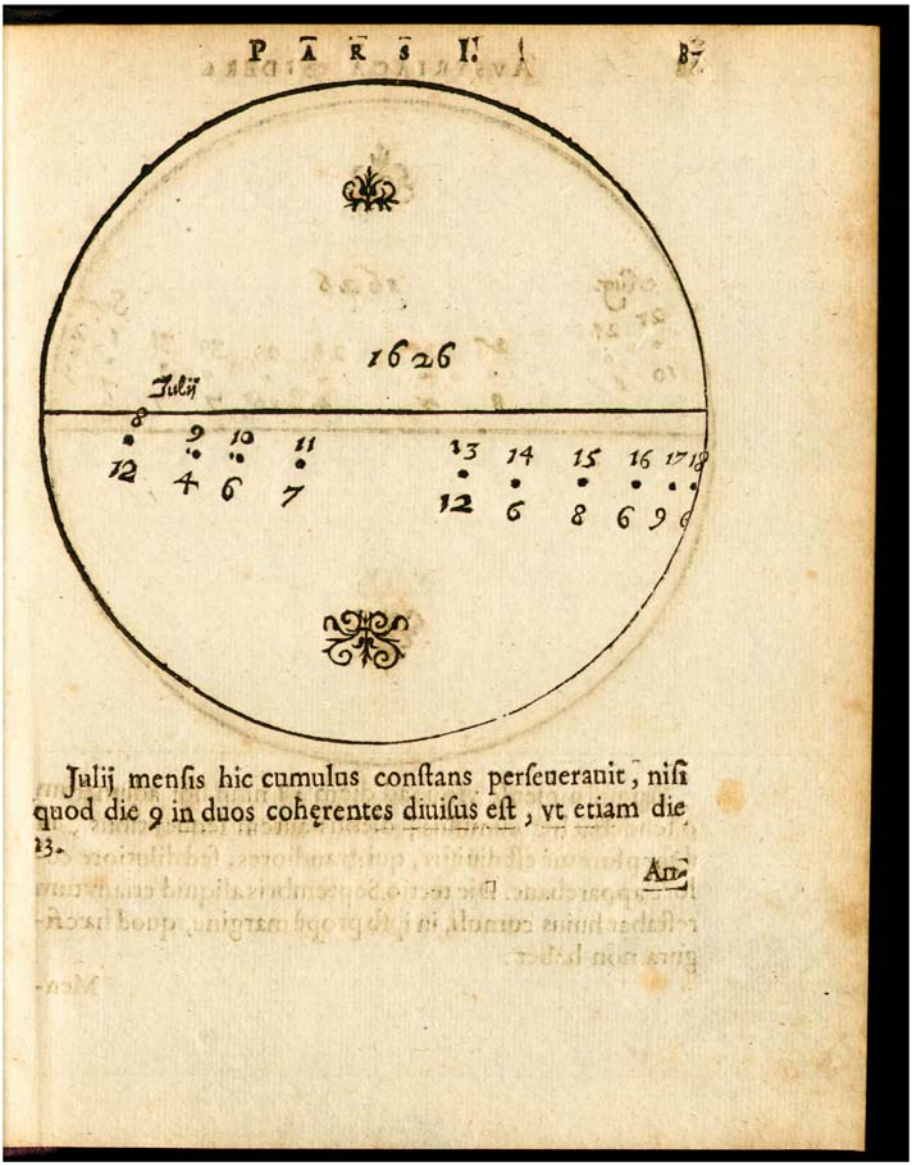


Figure 25. Charles Malapert, *Austriaca sidera heliocyclia, astronomicis hypothesibus illigata.* Douai, France, 1633. Zurich, ETH-Bibliothek Zürich. https://doi.org/10.3931/e-rara-2199

embrace all of Galileo's discoveries but keep the old physics in place with the Tychonic system of the world–a hybrid of the Aristotelian-Ptolemaic and Copernican systems in which all traditional planets circled the Sun, but the Sun and Moon revolved around a stationery Earth. Tycho Brahe laid out his scheme in *Astronomiae instauratae progymnasmata*, which Bernardino Spada owned in two editions.[99]

[99]Tycho Brahe, *Astronomiae instauratae progymnasmata* (Prague, 1602 and Nuremberg, 1611). ASR, Notai Tribunali A. C., vol. 5933, fols. 761v and 763r.

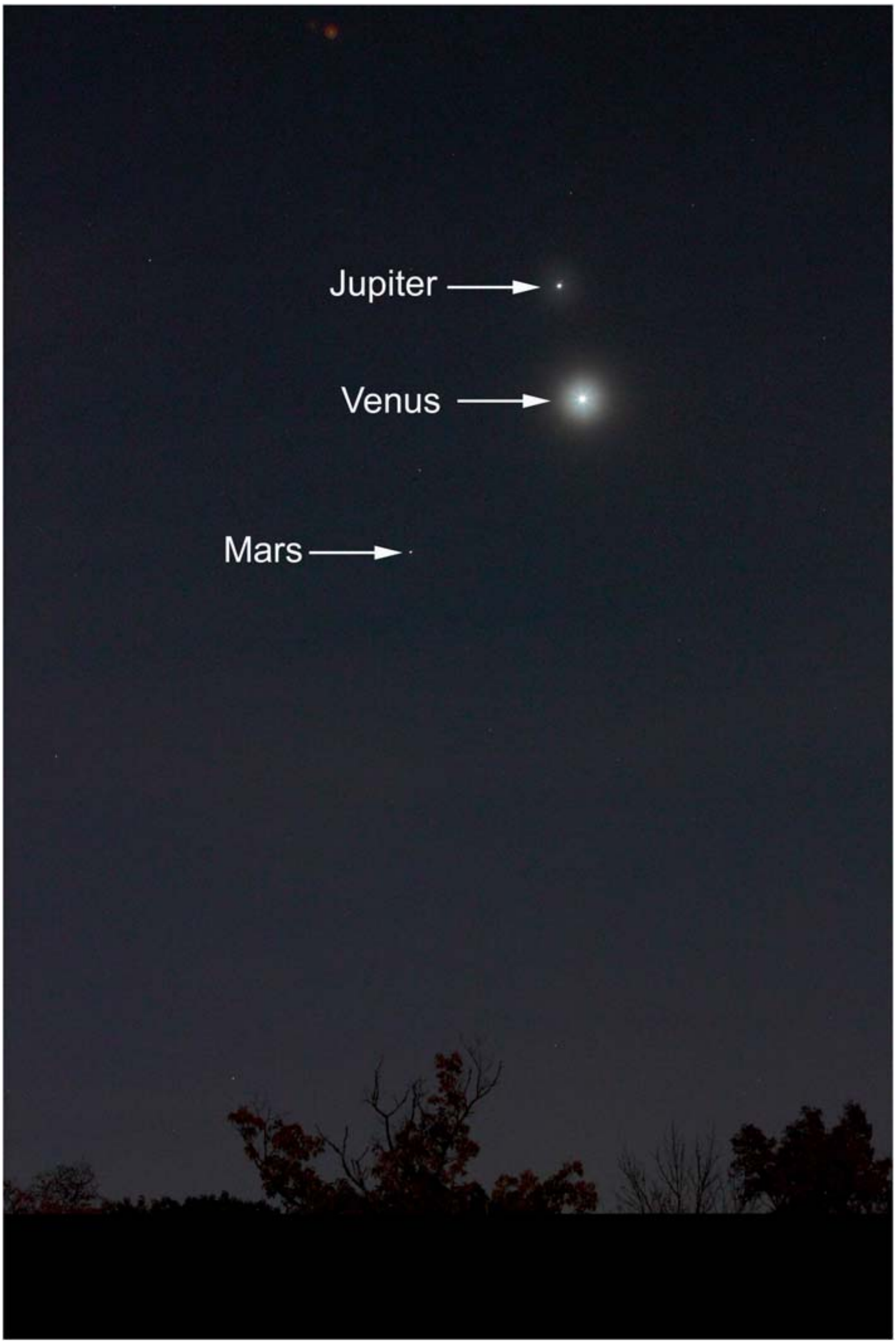


Figure 26. Modern, low-power image of Jupiter, Venus, and Mars in conjunction, showing the relative brightness, colour, and apparent size of the planets. There may be a moon of Jupiter visible to its upper right, but the bright dot could also be a star. Without repeated observations over several nights, an observer would not recognize the difference. Photograph taken October 27, 2015 by Al Takeda, Canon T1i DSLR, Canon 70-200 mm f/2.8 lens (FL = 70 mm), 1.4x magnification.

Figure 27. View of a conjunction of Saturn and Venus under magnification equivalent to very high power in Galileo's day (i.e. 25x-30x). Saturn (*on the left*) appears as a disk with two smaller disks or protrusions on each side, and Venus (*on the right*) is in a crescent phase. Although the modern exposure was made with far better optical equipment and sensitivity than early seventeenth-century telescopes offered, an observer today would be as hard pressed as Galileo to comprehend the meaning of Saturn's shape if he or she did not already know about its ring —a puzzle not solved until 1655 by Christiaan Huygens. Photograph taken June 30, 2007 by Al Takeda, Canon 20D DSLR, Celestron C-8 Schmidt-Cassegrain telescope plus f/6.3 focal reducer (FL = 1279 mm), 25.6x magnification.

Our interpretation of the celestial phenomena is not intended to be conclusive, as it is not clear at all what this detail represents. What we take to be clear, however, is that Tornioli obfuscated this area of the canvas and in this way, forced early modern observers to confront the difficulty of observing heavenly bodies. The ambiguities in this passage help to explain why early modern observers (such as the figures shown in Tornioli's canvas) came to rely on discussions with other observers and communal observations that made use of scientific instruments and of the explanatory power of images.

7. Conclusion

We have offered new interpretations of some of the scientific instruments, astronomical diagrams, and celestial phenomena represented in Tornioli's painting, and have suggested sources and exemplars among the books and scientific instruments in Virgilio and Bernardino Spada's possession. We have also taken care to situate components of the scene within the context of notable debates between astronomers and philosophers in the early modern period. The painting is neither for nor against the so-called new astronomy. Rather than choosing a particular scientific camp, it vividly illustrates contemporary debates about the meaning of astronomical phenomena and discoveries.

Over the course of the seventeenth century, scholars grew increasingly concerned with the education of the eyes of viewers, particularly those re-evaluating traditional written authorities in light of new empirical findings. We have argued that *The Astronomers* calls attention to the importance of civil conversation and communal observations juxtaposed with images and scientific instruments as tools for the schooling of sight and the debating of new knowledge claims. The acts of discussing and looking (at diagrams, illustrations, and nature), often with scientific instruments, which Tornioli shows in the painting, may well have been carried out of the canvas into the sphere of the painting's early modern spectators, who are likely to have modelled the experience shown. Because the painting is itself an object designed to be looked at, the subject matter and form could have worked in tandem to lead spectators to contemplate the process of observation. In front of *The Astronomers*, observers may have seen and argued about the meaning of elements in the painting, and they may have considered the challenge of transmitting theories, beliefs, and facts through both word and image.

Acknowledgements

We thank Katharine Park for introducing us. We thank Marina Cotugno, Marco Faccini, and Al Takeda for assistance in procuring images for this article. Thanks are due to John Heilbron and Joseph Connors. We are grateful to the anonymous peer reviewers for their insightful comments, and we thank Mordechai Feingold and Jed Buchwald for their encouragement. Selections from this paper were presented at the XXXVIII Scientific Instrument Symposium in Havana in September 2019 and at the Renaissance Society of America meeting held in Toronto in March 2019.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by Villa I Tatti, the Harvard University Center for Italian Renaissance Studies, under the Robert Lehman Fellowship; and the American Council of Learned Societies.

ORCID

Sara J. Schechner http://orcid.org/0000-0002-6335-1399