2. The Context of the Artists: Astronomy and its New Representations

https://doi.org/10.1017/S0269889701000333 Published online by Cambridge University Press

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Gazing Hands and Blind Spots: Galileo as Draftsman*

The Argument

The article deals with the interrelation between Galileo and the visual arts. It presents a couple of drawings from the hand of Galileo and confronts them with Viviani's report that Galileo had not only wanted to become an artist in his youth but stayed close to the field of visual arts throughout his lifetime. In the ambiance of these drawings the famous moon watercolors are not in the dark. They represent a very acute and reasonable tool to convince the people who trusted images more than words. The article ends with Panofsky's argument that it was Galileo's anti-Mannerist notion of art that evoked a repulsion of Kepler's ellipses. It tries to show that it was again an aesthetical prejudice that hindered Einstein from accepting Panofsky's theory.

I. Cigoli, Galileo, Michelangelo

The interrelation between Galileo Galilei and the artists of his time is still a major problem to be solved.[1] The most spectacular event happened in Rome. In the year 1610, the Roman painter Ludovico Cigoli was entrusted with the task of painting the chapel of Pope Paul V in Santa Maria Maggiore. The complicated project included a depiction of the Queen of Heaven standing on the moon in the central axis of the cupola. Surprisingly, in 1612 the painter frescoed the moon under the feet of the Mary with an uneven surface (fig. 1). The lunar sphere, only half lit, shows shadows and streaks of light in its illuminated part, suggesting heights and

* This paper was presented in different forms at the Hamburger Kunstakademie in June 1993, as an inaugural lecture at the Humboldt University in December 1994, and at the Zürich Galilei-Symposium from January 1996. Parts of it were published under the title, "Galileo Galilei als Künstler" (Bredekamp 1996a); parts were published under the title, "Zwei frühe Skizzenblätter Galileo Galileis" (Bredekamp 1996b) and parts appeared as Bredekamp 1995, 366ss. I am grateful to Jürgen Renn for his critique and help.

[1] Recently, attempts have been made to parallel Adam Elsheimer's moon on his copper "Flight to Egypt" which he worked on 1609 in Rome, with Galileo's results of his observations of the moon from the same year (Cavina 1976), or to find a reflection of the surface of the moon which Galileo had detected in the work of Artemisia Gentileschi, a close friend of Galileo (Garrard 1989, 334s). A quite recent study tries to illuminate the whole horizon of interrelation between artists and scientists of the early Seicento, mainly Galileo (Reeves 1997).

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Figure 1. Lodovico Cigoli, Moon Madonna, cupola fresco in the Capella Paolina of Santa Maria Maggiore, Rome.

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depths, as if the flawless moon had suddenly contracted a case of the measles or smallpox. Thus Cigoli confirmed the illustrations of the moon in Galileo's "Sidereus Nuncius" which had been published two years before.[2]

That Cigoli painted the irregular surface of the moon at a time when Galileo's lunar observations were still controversial is one of the Roman contradictions of the time. Members of the progressive wing of the Church which strove for its reconciliation with modern science were able to support Galileo's view of the moon all the more as Apocalypse 12 allowed to connect the spotted moon with evil and heresy over which the *Immacolata* celebrated her victory.[3]

The orthodox view, instead, resisted massively. Up to this point the moon, like all celestial bodies, had been thought to be a perfectly round, platonic form, which unlike the earth — "the filth and dregs of the universe" bore not the faintest irregularity.[4] In its smooth, fully illumined form it served as a symbol of the Mariological Church, still appearing as such, for example, in Bartolomé Esteban Murillo's *Immacolata* of ca. 1660.[5] In 1616, only four years after completion of Cigoli's fresco, a cross section of the chapel for Paolo de Angelis' book on Santa Maria Maggiore showed Mary standing on a smooth, unmarred sphere in accord with traditional iconography.[6] Not until the restoration work of 1931 was it discovered that the engraving had falsified the moon of the fresco by perfectly smoothing its surface.

In 1612 Cigoli honored Galileo a second time, and more successfully. He compared him to Michelangelo, the breaker of the Vitruvian rules and rebel against the order of tradition: "And I think that the same happens to you as to Michelangelo when he started to build outside the order of the others till to his times, where all of them unanimously, turning against him, said that Michelangelo had ruined the architecture with all of his misuse fare from Vitruv."[7]

Cigoli's bridging between Michelangelo and Galileo went beyond a metaphorical connection when Vincenzio Viviani, assistant and biographer of Galileo, dated Galileo's birthday in his biography one day after Michelangelo's death, February 19, 1564, and later, 1692, fixed it precisely on February 18.[8] Thus, in a remarkable

[2] Artists in Rome, and among them Cigoli, had used the telescope by themselves. Elsheimer might have used one of the earliest pieces in Rome already by 1610 (Cavina 1976, 142f.). The painter Domenico Passignano had made observations of his own before February, 1612 (Lodovico Cigoli to Galileo, February 3, 1612, in Galilei 1890–1909, 268). By March Cigoli was in possession of another telescope (Cigoli to Galileo, March 3, 1612, ibid., 287). On Cigoli, see Matteoli 1980; 1982; on Cigoli and Galileo: Faranda 1986, 95–96; Contini 1991, 110–112; Puppi 1992, 244ss.; Magani 1992, 145f.

[3] The events have been known since Erwin Panofsky's pioneering study of Galileo's relationship to art: (Panofsky 1954, 5; cf. more specific: Wolf 1991/92, 313; Ostrow 1996b, 233f.; Ostrow 1996a, 244ss.). The general context is given by Rivka Feldhay (Feldhay 1995).

[4] Blumenberg 1980, 23.

[5] Edgerton 1991, 231f; cf. Ostrow 1996b, 222–229; Reeves 1997, 144ss.

[6] de Angelis 1621, 194.

[7] "et mi credo avengha lo istesso come quando Micelagniolo cominciò a architetturare fuori del'ordine degli altri fino ai suoi tempi, dove tutti unitamente, facendo testa, dicevano che Micelagniolo avea rovinato la architettura con tante sue licenze fuori di Vitruvio" (Ludovico Cigoli to Galileo, July 7, 1612, in Galilei 1890–1909, XI:361).

[8] The components of the complicated story of the investigation and manipulation of Galileo's

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effect of providence, the relay baton of the immortals seemed to have passed directly from Michelangelo to Galileo.

At first glance one could take the bridging between Galileo and Michelangelo as a merely rhetorical fantasy, given in order to connect Galileo with the artistic quality of the "uomo universale." But Viviani's manipulation was more than just an act of piety. Michelangelo's reincarnation in Galileo was meant to transfer the artist's fame as a supporter of the Counter-Reformation to the reputation of Galileo, whose condemnation in 1633 continued to be a dark spot of his life.[9] On the other side Galileo, who had been protected by the Medici, could transform Michelangelo, the defender of the Florentine republic against the imperial army that brought the Medici to power, a partisan of the ruling family. Thus both "profited" crosswise from each other in the name of Florence and the Medici.

The connection between Michaelangelo and Galileo became a *topos*. Even still Kant spoke of the "metempsychosis of three geniuses: Michaelangelo, Galilei, and Newton,"[10] and in 1793 the historian Giovanni Battista Clemente de' Nelli confirmed the overlapping of Michaelangelo's death and Galileo's birth.[11] Not until 1887 did the editor of the collected works of Galileo, Antonio Favaro, find out that this coincidence had occurred not through a portentous play of nature, but rather through careful manipulation.[12]

II. Artistic Tools

Viviani, using Giorgio Vasari's Lives of the Most Famous Painters, Sculptors and Architects as a model, had also spiced Galileo's biography with motifs from the youth of Giotto.[13] There were reasons to give Galileo an artist's aura as he was close to being an artist in social terms and in practice. From the beginning, Galileo turned the duties usually reserved for artists to his advantage in order to become an employee of the Medici court, for after centuries of tenacious social advancement, it was the court artist that embodied Galileo's dream of a fulfilled life of research: an independent position free of public teaching responsibilities and without specific work obligations.[14]

It is well known that, following the maxim of his friend and supporter Giovanni

birthday are reported by Michael Segre (Segre 1989, 221–225; 1991, 116–122). Most important was the marble inscription at the facade of Viviani's house in the Via dell'Amore (Via San Antonio), nr. 11, prepared in 1692, claiming the day of Michelangelo's death as the day of Galileo's birth (Favaro 1880, 41).

[9] Galluzzi 1994.

[10] "Metempsychosis dreyer genies: Michelangelo, Galilaei und Newton" (Kant 1923, 826; cf. Maio 1978, 3, 11 n.2).

[11] de' Nelli 1793, 21–22.

[12] Favaro 1887, 703–711.

[13] Segre 1989, 219ss., 225f.; 1991, 112–122.

[14] Westfall 1984, 191. The rise of the court artist is studied by (Warnke 1985).

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Ciampoli, "blessed is he who is able to strengthen his fortune through gifts,"[15] Galileo proffered his research results and inventions as presents to the powerful and highly-placed. Among them one finds his instruments such as the compass and the telescope as well as his books and letters and even his astronomical discoveries.[16] No less significant is the fact that Galileo followed one of the traditional prerogatives of the court artist, designing emblems and coats of arms for the potentates, in which the glory of their rule could be manifested to the senses. Thus Jacques Callot, a court artist to the Medici in Florence at that time, sketched a series of heraldic designs.[17]

With the same intent and comparable iconography, Galileo designed an emblem for a Medici in the year 1608. First he purchased a round lodestone for the crown prince Cosimo de' Medici in order to win his favour — an investment in the future, as it were. The spherical form was, of course, a play on the *palle*, the six balls that adorned the Medici coat of arms. On the occasion of Cosimo's wedding, Galileo suggested as an impresa a round lodestone to which a series of small iron balls would adhere:

> That the magnetic sphere ... is admirably suited to the person of the most illustrious prince is apparent: first, because the balls are an ancient insignia of the Medici house, and furthermore, because it has been extensively written by the greatest philosopher and confirmed by clear demonstration that our earthly world in its primary and universal substance is nothing but a great magnetic sphere; and since the name Cosmo [cosmos] signifies the same thing as mondo [world], one could understand our great Cosimo under the most noble metaphor of the magnetic sphere.[18]

After the lodestone and its emblematic elaboration, Galileo handed over four additional spheres in the year 1610. With the help of his telescope, Galileo had discovered four planets in the field of Jupiter, which he bequeathed to the grand duke of Florence as a divine gift:

> The creator of the stars himself now seemed to direct me through clear signs to ascribe these new planets to the glorious name of your Highness before all others .... Because I have discovered these stars, unknown to all previous

[15] "Beato chi col donare può accellerare la sua fortuna!" (Ciampoli 1978, 232; cf. Biagioli 1993, 39).
[16] Biagioli 1993, 48ss.
[17] Callot 1971, 1432.
[18] "Che poi per la palla di calamita acconciamente si additi la persona del Ser.mo Principe, è manifesto: prima, per esser le palle antica insegna della Casa; in oltre, essendosi da grandissimo filosofo diffusamente scritto, et con evidenti dimostrazioni confermato, altro non essere questo nostro mondo inferiore, in sua primaria et universal sustanza, che un gran globo di calamita, et importando il nome Cosmo il medesimo che mondo, potrassi sotto la nobilissima metafora del globo di calamita intendere il nostro gran Cosimo." (Galileo Galilei to Christina of Lorraine, September 1608, in Galilei 1890–1909, 10:222). For more on the entire context cf. Biagioli 1993, 120ss.; Bredekamp 1993, 59ss.

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> astronomers, under your protection, most serene Cosimo, I am entirely justified in my decision to call them by the august name of your family.[19]

Herewith the Medici were immortalized: released from the contingencies of earthly mutability, their glory now hovered in the astral plane, inseparably bound to the stars.

Of Galileo's iconographical and emblematical enterprises there is also visual evidence. It must have been around 1610 that Galileo recorded two designs for Medici coats of arms on the reverse of a page covered with numerous tables (fig. 2).[20] Galileo first jotted down a rough sketch of the cartouche of the coat of arms in which the crown in the middle shows a fleur-de-lis; the uppermost of the six individual spheres arranged below likewise shows the petals of the lily. The lower design confirms this arrangement, but chooses a more oblique perspective to better emphasize the depth of the cartouche and more concretely suggest the embedding of the spheres.

Designs of this sort for emblems and coats of arms also served as a kind of calling card for the artist himself. When Leonardo da Vinci was in the service of the Milanese court, he designed an emblem with a compass whose needle pointed to a sun with the three lilies of the French king. It was to receive the epigraph, "Whoever is fixed on a star does not waver." Presumably it was meant not only as a declaration of loyalty to the Milanese duke, but also as a hint by Leonardo to be called by the French king.[21] That Galileo considered the possibility of bringing the moon, as well, into association with Cosimo ("cosmos") Medici is suggested by the line at the left edge of the page bearing the coat of arms, at the lower end of which hangs the crescent of a half moon. Galileo may also have intended to include the sphere of the moon among the six Medici balls.

Galileo attained the fulfillment of all his wishes in 1610 when he was given the post of court philosopher with a salary among the ten highest in Tuscany. It was more than half again as great as that of the best-equipped court sculptor, Giovanni da Bologna.[22] At once, he was freed from teaching. And so he assumed that privileged status which Michelangelo introduced into the history of labor law after he took over absolute control of the construction of St. Peter under no obligation, responsible to God alone.[23] With this status, as has been argued, Galileo had reached his goal of becoming the "Michelangelo of mathematicians."[24]

[19] "Ut autem inclito Celsitudinis tuae nomini prae ceteris novos hosce Planetas destinarem, ipsemet Siderum Opifex perspicuis argumentis me admonere visus est...Quae cum ita sint, cum, te Auspice, COSME Serenissime, has Stellas superioribus Astronomis omnibus incognitas exploraverim, optimo iure eas Augustissimo Prosapiae tuae nomine insignire decrevi." (Galilei 1610, 56f.). On this act of bequeathal, cf. (Biagioli 1993, 52f.).

[20] In Mss. Galileiani, 50:32^r.

[21] (Warnke 1985, 75; cf. Reti 1959, 40), who alone surmises a political significance.

[22] Biagioli 1993, 104.

[23] Vasari 1962, 84.

[24] Biagioli 1993, 86f.

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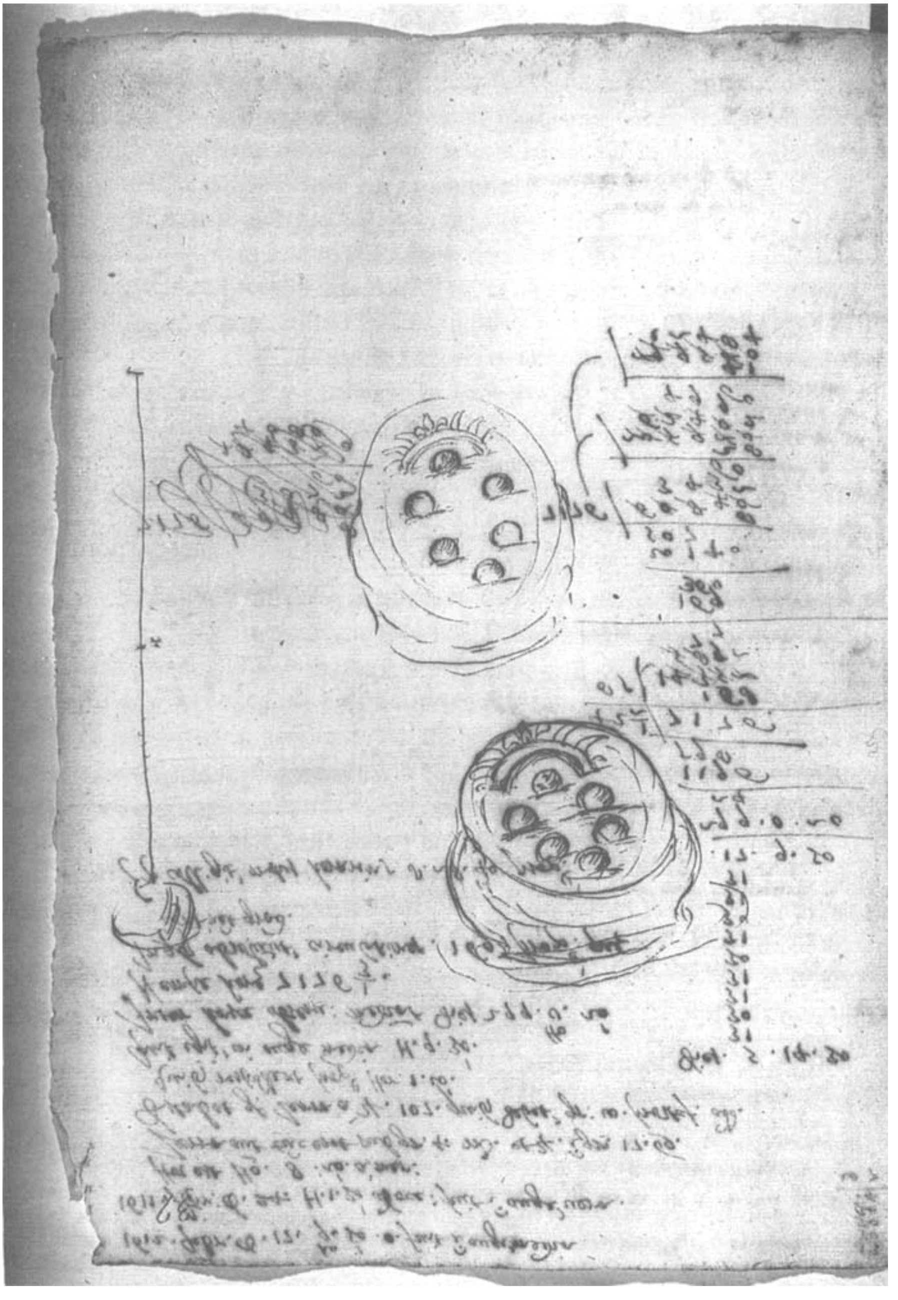

Figure 2. Galileo Galilei, design for Medici coat of arms. Ink drawing, Florence, Biblioteca Nazionale Centrale, MS. Gal. 50, fol. 32r.

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III. Pen Drawings

The affinity should not be carried too far, but there do indeed exist intimations of a connection beyond mere similarity of artistic tools and working conditions. The painter Cigoli and Galileo had been friends since around 1585, when they had studied with Ostilio Ricci, the court mathematician, who later taught mathematics at the "Academia del disegno" in Florence, in the house of the artist and engineer Bernardo Buontalenti.[25] Viviani was surely reflecting this situation when he reported that Galileo busied himself "with great delight and marvelous success in the art of drawing, in which he had such great genius and talent that he would later tell his friends that if he had possessed the power of choosing his own profession at that age, ... he would absolutely have chosen painting."[26]

Viviani's remark is confirmed by several drawings which are preserved in the manuscripts of the Biblioteca Nazionale Centrale of Florence, but which were not included in the national edition, since they seemed to contribute nothing to the image of Galileo. Until the scanned version of all the manuscripts is made available we may expect other surprises as well, upon inspection of the precious original manuscripts.[27]

Among the earliest evidence are two of three pages from Galileo's examination essay of 1584 on Aristotle's *De coelo*. These two pages form a protective binding at the front and back of the second part of the treatise.[28] It is conceivable that the pages served as a covering from the beginning and that Galileo used them as a surface for drawing and writing when the treatise was returned to him. This, however, is unlikely in view of the fact that older scribblings are found on one of the two pages. It is more probable that Galileo, having received back his manuscript, found a sheet of paper lying in his room that was suitable in size and thickness to serve as a protective covering for each of the two parts. At first glance the appearance of these pages might give the impression of a non-explainable complexity, but it can be, at least hypothetically, put into a differentiated order.

The obverse, which presents a rather confused impression, shows numbers and figures written in pen (fig. 3), stemming without a doubt from Galileo's hand.[29] In

[25] (Olschki 1965; Settle 1971; Masotti 1970–1980, XI:405f.; Wazbinski 1987, I:283; Reeves 1997, 6). On the Academia, see also (Reynolds 1974).

[26] "Trattenevasi ancora con gran diletto e con mirabil profitto nel disegnare; in che ebbe così gran genio e talento, ch'egli medesimo poi dir soleva agl'amici, che se in quell'età fosse stato in poter suo l'eleggersi professione, averebbe assolutamente fatto elezione della pittura" (Viviani 1890, 602).

[27] The project is presently undertaken by the Biblioteca Nazionale Centrale and the Istituto e Museo della Scienza in Florence. Galileo's manuscripts on mechanics have been made available on the Internet as a result of a joint project of the Max Planck Institute for the History of Science, the Biblioteca Nazionale Centrale and the Istituto e Museo della Scienza in Florence under:
http://galileo.imss.firenze.it/ms72/index.html
http://www.mpiwg-berlin.mpg.de/Galileo—Prototype/MAIN.HTM. On first scale the manuscripts on fortifications in the Ambrosiana, Milan, could evoke new insights: (Tabarroni 1984).

[28] (Mss. Galileiani, 46:56–102). The first quire extends from fol. 1–55. I am grateful to Michele Camerota for calling my attention to these pages.

[29] Mss. Galileiani, 46:56^{r}.

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Figure 3. Galileo Galilei, sketch, ink on paper, ca. 1584 and earlier. Florence, Biblioteca Nazionale Centrale, MS Gal. 46, fol. 56r.

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the upper half of the page a woman is shown from behind, her curls partly pinned up and partly falling onto her shoulders. Her left arm is raised, the hand swelling as if, perspectively enlarged, it were swinging back toward the viewer. This extreme and obviously unsuccessful experiment with the possibilities of perspectival foreshortening is marked through with every sign of displeasure. Draped over the woman's left shoulder is a robe that evidently covers her thighs as well. Her legs are turned to the right and bent so that the more vigorously rendered right arm can reach back toward the feet.

No direct model is discernible, but possible comparisons can be made with the female figures of the Neptune fountain of the Piazza della Signoria in Florence, created before 1575 in the workshop of Bartolomeo Ammannati. Even closer are individual figures from Ammannati's Fountain of the Elements for the Palazzo Vecchio, which in the 1580s was located in the garden of the Villa Pratolino. Giovanni Guerra's drawing of the figures after their removal to the grounds of the Palazzo Pitti,[30] presumably drawn from memory around 1598 and arranged into an ensemble, enables a comparison in the same graphic medium (fig. 4). The "Fiorenza" bending back on the right in the middle of the arch comes relatively close to the head and shoulder of Galileo's female figure, while the Hippocrene shows a similar, if more relaxed, seated posture. These somewhat vague references are not intended to suggest Galileo's dependence on Ammannati, but rather serve to elucidate the formal climate in which Galileo sought to orient himself.

The other motifs appear too unspecific to necessitate a search for models. Below and to the left of the female figure, a horse's head is sketched, flanked by the head of a bearded man and writing exercises for the letter "g." The lower area contains red chalk drawings that appear to stem from the hand of a child: columns of squares and geometric building blocks, like those used in the game of hopscotch.

In its subdivision into three areas, this page is no anomaly. Paper was available in any form,[31] but it was not cheap, and as a rule was reused further times. As mentioned before, the relation between Galileo and Michelangelo suggested by Viviani should not be exaggerated, but chance has it that an early example from the hand of Michelangelo bears witness to a similar use of the page (fig. 5).[32]

While the obverse bears an entry from the year 1501, the reverse is covered with written characters and three sketches: a right hand, a left leg seen from the front, and a nude seen obliquely from behind. Nevertheless, both sides are executed in the same ink and with the same pen, so we may assume that the approximately 12-year-old Michelangelo undertook writing and poetry exercises in different styles of handwriting, as may have been prescribed by his grammar teacher: at the top, the script of official business, and below, that of personal letters and notes.

[30] Heikamp 1978, 146.

[31] (Kemp 1979, 59). On the significance of drawing, see (ibid., 57ss.; cf. also Westfehling 1993, 98ss.).

[32] (Florence, Archivio Buonarroti, II/III:fol. 3^{v}), in (Dussler 1959, 56, No. 27, Fig. 35); the interpretation followed here stems from (Perrig 1991, 68ss.).

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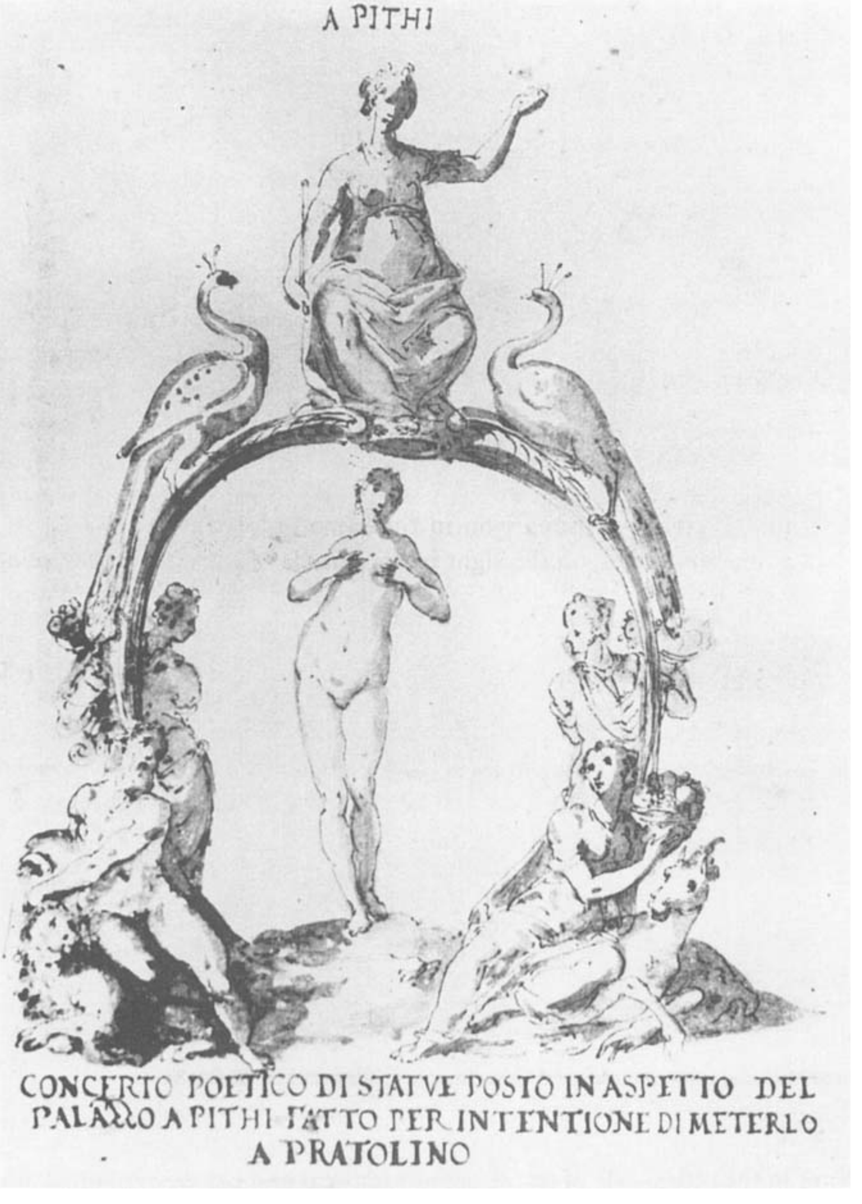

Figure 4. Giovanni Guerra, the Ammannati fountain, drawing, ca. 1598. Vienna, Graphische Sammlung Albertina.

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Figure 5. Michelangelo, Sketches, Archivio Buonarr, Florence, II/III fol. 3v.

The lines in the older style of script are nonsensical and can be explained as mere writing practice. In addition to the names of his uncle and brother, Michelangelo here wrote the designations for different vocations and his surname in several variations: "Buonarotto" in the fourth line, but "Buonnarootto" in the fifth.

Along with the evident deficiencies of a beginner, the drawings immediately manifest the self-willed development of the autodidact as well. In the sketched hand, the enlarged knuckle areas and the swollen ball of the thumb, as well as the alteration in the two first joints of the index finger, bear witness to the groping character of the attempt, while the perspective foreshortening already bespeaks a

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willingness to tackle problems characteristic of both Michelangelo here and Galileo later.

In its mixture of writing and drawing exercises, the page from Michelangelo evinces a structure similar to that of Galileo's sheet from the Aristotle treatise. The latter was presumably filled in three stages: first, the red chalk drawings of the perhaps 5 to 10-year-old, then the writing exercises of the 12 to 15-year-old, and finally the calculations and drawings of the student, presumably in his early twenties.

The reverse side of the second quire of Galileo's examination treatise, as well, shows a similar pattern of use (fig. 6).[33] Here, however, figural representations

Figure 6. Galileo Galilei, sketch, ink on paper, ca. 1584. Florence, Biblioteca Nazionale Centrale, MS. Gal. 46, fol. 101v.

[33] Mss. Galileiani, 46:fol. 101ᵛ.

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predominate. In the upper half of the page, a man pulls a figure upward toward himself; the two rounded breasts presumably indicate the figure is a woman. In a second layer, turned 90 degrees, the outline of a horse's head appears amid writing exercises, while an awkward hand with widely spread thumb and index finger opens up toward the right, a subject Michelangelo had also sketched; clearly it belonged to the usual material of the autodidact.

Below and to the left are the legs of a figure clad in tight-fitting breeches, while at the bottom of the page there appears a nymph, whose outline Galileo attempted to correct with numerous strokes of the pen. With her right hand covering the pubic area and her left arm slightly bent, the nymph resembles the antique Venus Felix of the Belvedere court in Rome (fig. 7); with her nude body bent slightly forward,

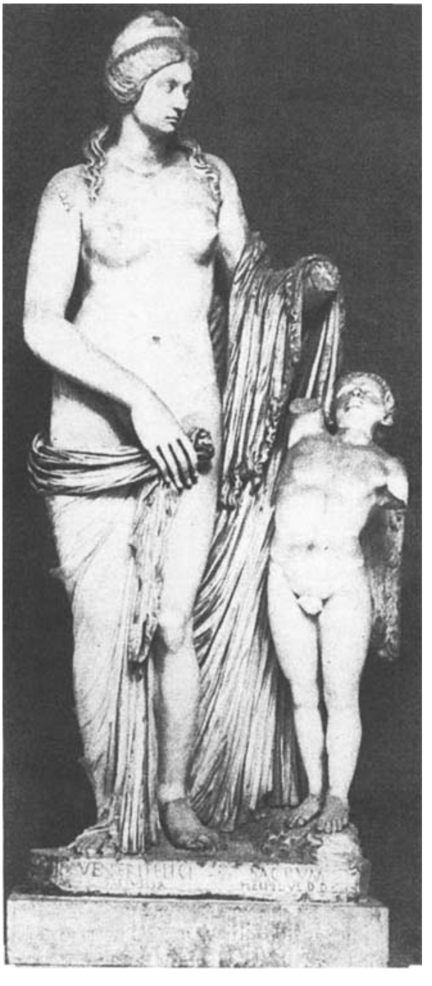

Figure 7. Venus Felix, Roman statue. Second century A.D., Rome, Belvedere.

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however, she is also reminiscent of the Medici Venus of the Uffizi Tribuna (fig. 8).[34]

In their mixture of amateurish incompleteness and ambitious effort, the pages bear witness to a conflict. The head of the male figure is not unskillful in its effect, and the face of the nymph reveals practice. At the least, the sketches bespeak a certain familiarity with the qualitative level of sixteenth-century drawing. But to be sure, the disegni of the young Galileo are by no means masterpieces, and one could argue that it was best for Galileo that he did not follow a career as an artist.

Figure 8. Medici Venus, Greek copy of the bronze Venus after Praxiteles. Florence, Uffizi (Tribuna).

[34] Haskell 1981, 323f., 325ss.

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On the other side, even following this conclusion, two problems remain. The one lies in the question up to what degree Galileo saved his artistic ambitions and his figural thinking to his mathematical sketches. This is a subject in itself, which up to this point has not even been addressed, let alone explained. In one of the stereometric drawings,[35] for example (fig. 9), the freely drawn stroke, correcting itself on the curves, accords well with the repeatedly redrawn outline of the upper body of the nymph (fig. 6).

The second problem lies in the fact that Galileo continued to draw, and that some later pieces which have survived cannot be judged but masterly. Viviani's *vita* notes that even after his period of education, Galileo maintained "such a natural and proper inclination to the art of drawing, and in time acquired such exquisite taste, that his opinion on paintings and drawings was preferred to that of the

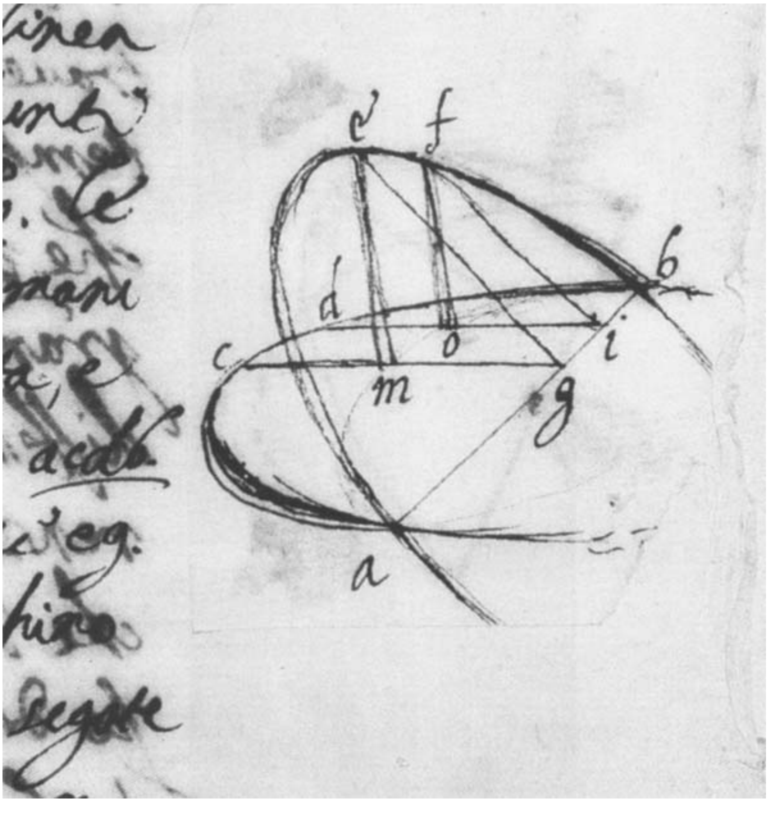

Figure 9. Galileo Galilei, stereometric drawing. Florence, Biblioteca Nazionale Centrale, MS. Gal 57, fol. 35r.

[35] Mss. Galileiani, 57:fol. 35.

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foremost professors — even by the latter themselves."[36] These words find their confirmation in the original manuscript of the Sidereus Nuncius of 1609. Hastily sketched between calculation tables of the Medici moons are two landscapes dating from ca. 1610 (fig. 10),[37] executed in a stroke that is remarkably free and almost modern in its spontaneous assurance. In the upper stripe, a cupola projects upward to the left while buildings and trees form a staggered boundary to the right. Sails indicate that this complex is located on the water. Below, the second scene shows a sharply accentuated river course. On the opposite bank of the river lies a castle or fortified village, while in front, four sails are once again sketched in with a singularly free hand.

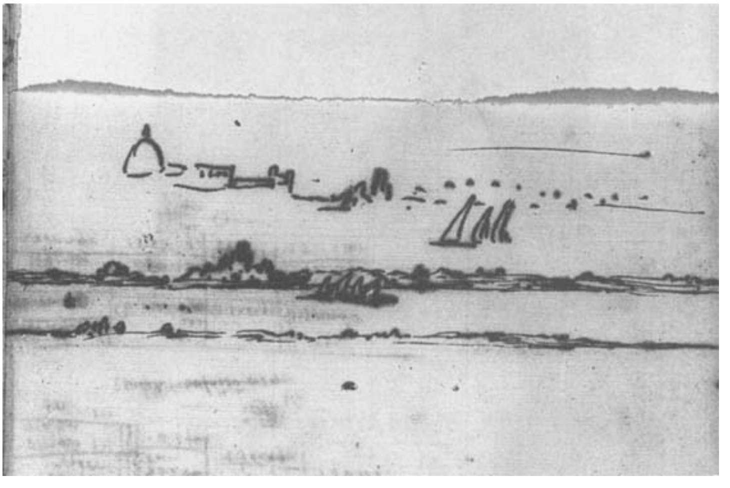

Figure 10. Galileo Galilei, two rivers, ink drawing. Florence, Biblioteca Nazionale Centrale, MS. Gal. 48, fol. 54v.

Whether these sketches were drawn from life or represent the free product of Galileo's imagination — a digression during his calculations for the moons of Jupiter — is difficult to say; they may be scenes from the banks of the lagoon in Venice. In any case, in their simple, confident form the sketches are convincing.

The impression of the almost transhistorical modernity that imbues the medium of drawing is likewise awakened by this view of a townscape extending across two plateaus connected by a wall running diagonally upward (fig. 11).[38] The light coming from the upper left allows the extremes of light and shadow to appear in contrasting strips.

[36] "Ed in vero fu di poi in lui cosi naturale e propria l'inclinazione al disegno, et acquistovvi col tempo tale esquisitezza del gusto, che 'l guidizio ch'ei dava delle pitture e disegni veniva preferito a quello de' primi professori da' professori medesmi" (Viviani 1890–1909, 602).

[37] Mss. Galileiana, 50:fol. 54^{v}.

[38] Mss. Galileiana, 50:fol. 61^{v}.

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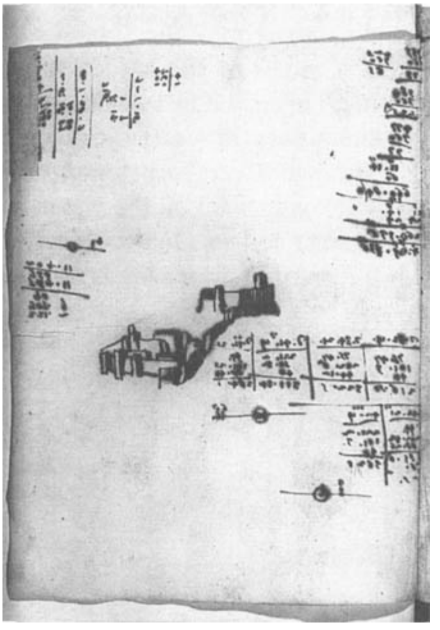

Figure 11. Galileo Galilei, view of a townscape extending across two plateaus connected by a wall running diagonally upward (Mss. Galileiana, 50:fol. 61ᵛ).

IV. Moon Watercolors

The drawing of a townscape explores a problem of vital importance for Galileo's study of the surface of the moon and for the wash drawings included with the Sidereus Nuncius manuscript; six of them on the recto of fol. 28 (fig. 12)[39] and a seventh one on the verso. The juxtaposition of the six drawings on a single sheet suggests that in all probability, Galileo transferred them as a group from ad hoc sketches that have now been lost.[40]

Clearly a reference to the Medici was intended, for on the verso the additional moon is included along with the horoscope for May 2, 1590, the birth date of Cosimo II de' Medici.[41] However, if Galileo sought to establish a connection here, he later abandoned the attempt, perhaps because, with the dedication of the moons of Jupiter to the Medici, he had already attained his dream of a one-man institute for advanced study, created just for him, by September 1610.

The moon images correspond to precise dates and times of day. Four drawings

[39] (Mss. Galileiana, 48:fol. 28ʳ). For the most recent discussion, with earlier literature, see (Whitaker 1989, 122ss.; Frieβ 1993, 121ss.).
[40] Gingerich 1975, 87f.
[41] Mss. Galileiani, 48:fol. 28ᵛ.

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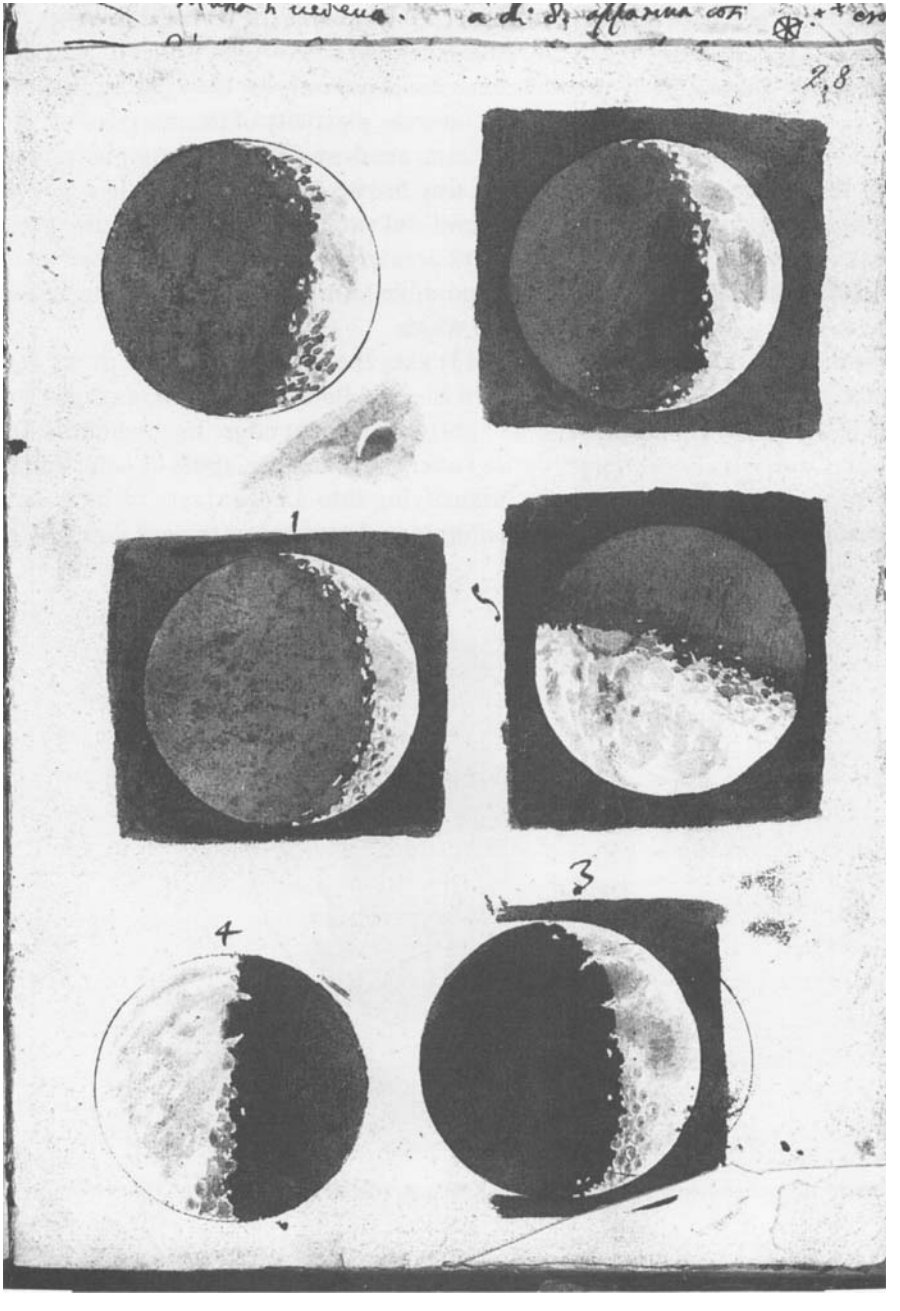

Figure 12. Galileo Galilei, six phases of the moon, ink drawing. Florence, Biblioteca Nazionale Centrale, MS. Gal. 48, fol. 28r.

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show the phases of the moon between November 30 and December 2, 1609; two others represent the moon of December 17–18; while the isolated, seventh moon on the verso, with the star Theta Librae emerging to the right, is that of January 19, 1610.[42] But Galileo's drawings are remarkable not only for their precision, but also for their technique, using a brush to render the plasticity of the moon's surface. All of the circles, with diameters of 57–59 mm, are drawn with pen compasses; in each case, the center point is marked by a tiny brown dot. This area still shows light patches going down to the picture ground and varies within itself, but also presents streaks of further shadowing of the dark area of the moon. The use of brown color applied in differing densities made it possible to modulate from a deep, shadowy tone to a beige that almost fades into white.

Galileo's first moon drawing (fig. 13) uses the base color of the paper for the lighted area illuminated by the sun. In the middle of this region, a cloud-shaped area drifts to the right, darkening slightly at its right edge. In the middle of this "cloud," applied almost imperceptibly over the first layer, spots of color run from the upper left to the lower right, intensifying into a color layer of their own. A second bulge in the upper half of the illuminated area points toward the right; here,

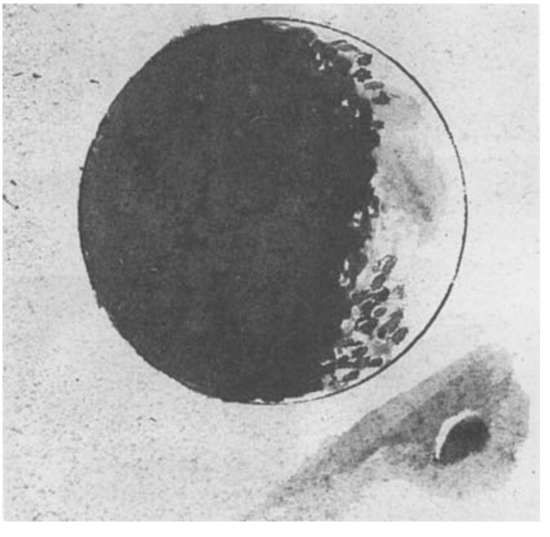

Figure 13. Lunar phase from 11.30.1609, 6–8:00 p.m. (detail from fig. 12; all times from Ewan A. Whitaker).

[42] The precision of Galileo's drawings has been doubted, but since Righini's conclusion that Galileo was "in fact, a remarkably faithful recorder of his visual experiences," the picture has changed completely (Righini 1975, 76; cf. Drake 1976; Righini 1978, 26–44; Whitaker 1978 [in this article Whitaker collected comparable photographs of each of the corresponding phases of the moon. He relied on the visible contours of the boundary line between light and shadow, and not necessarily on the extent of the crescent]; Whitaker 1989, 122ss.; Shea 1990).

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too, similar spots and daubs were added. To the left, however, the brown grows darker in three layers of intensity. A small area attains the third color level, while to the left a "spot" lying horizontally above it is slightly darker; between them, another island deepens again by an almost imperceptible degree. This area blends into the dark side of the moon. This area still shows light patches going down to the picture ground and varies within itself, but also presents streaks of further shadowing of the dark area of the moon. In the lower right, tachistically applied daubs suggest a carpet of hills still illuminated by the sun and indentations already lying in shadow.

In order to render the growing contrast between darkness and intensifying light, additional shading is applied in the lower area of the second sphere (fig. 14), diminishing again to the left in streaks and stripes. The lighted crescent stands out from the dark ground with all the finesse of chiaroscuro, a veritable explosion of full sunlight. After the glaringly illuminated crescent and the abrupt contrast of the dividing line to the lunar night, the refined treatment of lighting continues with a diminishing of the darkness to reproduce the reflected light of the earth. Finally, the left edge of the moon becomes lighter than the transitional zone between light and shadow, so that a circular line drawn with particular strength is needed to

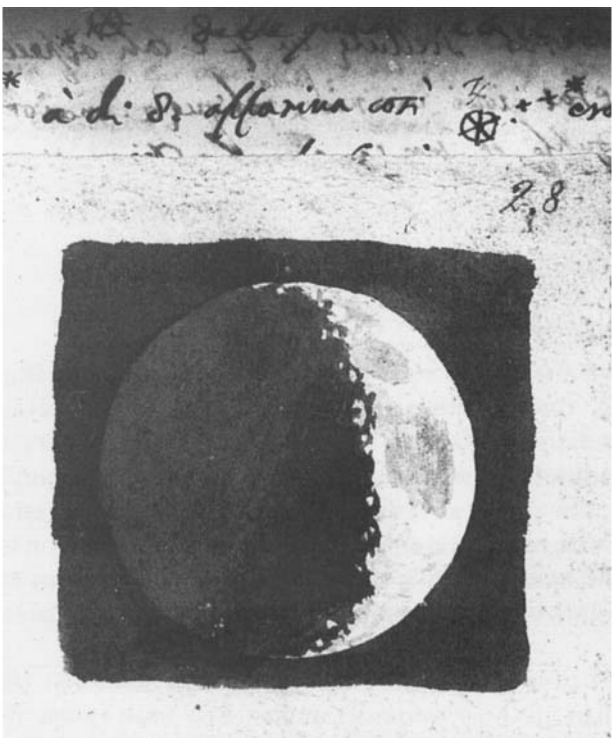

Figure 14. Lunar phase from 12.01.1609, 5:30 p.m. (detail from fig. 12).

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distinguish it from the night sky. Both the light and the dark side of the earth's satellite shine out into space with shimmering iridescence. Daubs of an additional rust-red color appear in the upper right corner and in two places in the lower and upper dark area of the moon. In their distribution they make no geographical sense, but obviously constitute an attempt to bring further visual interest to the representation.

The dark face of the third moon (fig. 15) is a trace lighter than that of the first drawing. Strangely, the deepest dark appears outside, on the upper and lower edges of the picture, as if to provide the sphere hovering in space with a color axis

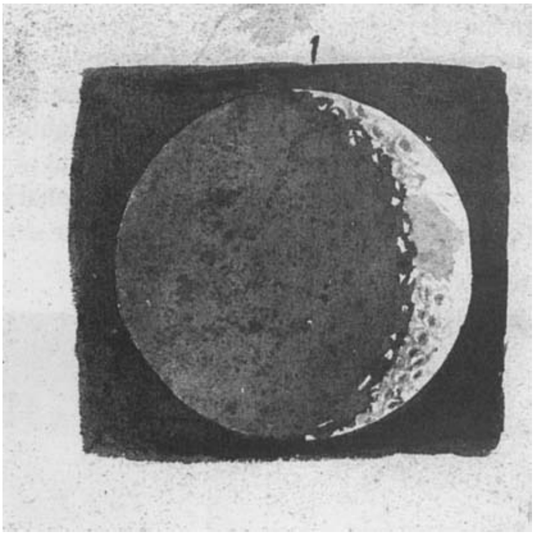

Figure 15. Lunar phase from 11.30.1609, 4:00 p.m. (detail from fig. 12).

as a kind of visual anchoring. Since the face of the fourth moon (fig. 16) is already half illuminated, the transitional zone from light to dark receives particular emphasis. A peculiarity is the giant mountain range, whose inner cliffs introduce a half-circle of shadow into the zone lighted from the left. Correspondingly there are other areas, too, that still or already lie in shadow as outposts or stragglers. Again, Galileo worked with reciprocal effects: on the dark side, the moon becomes lighter again toward the horizon, while the night sky behind darkens more intensely. Conversely, the dark of the sky diminishes on the opposite side to establish a color balance.

In the contrast zone of light and shadow, the fifth lunar disk (fig. 17) shows a stronger dark than all the previous examples. The sixth sphere (fig. 18) further intensifies the darkness of the night side against the line of contrast to the light. To the lower right, stippled flecks form a panorama of hills and craters.

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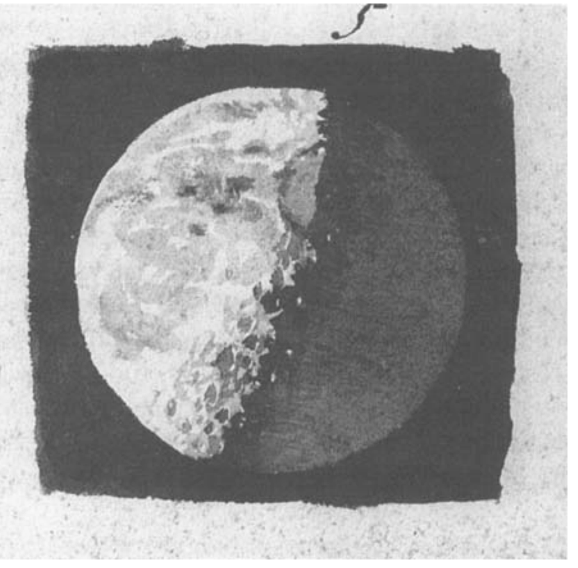

Figure 16. Lunar phase from 12.17.1609, 5:00 a.m. (detail from fig. 12).

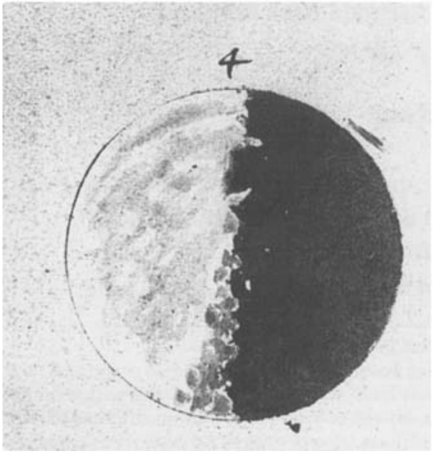

Figure 17. Lunar phase from 12.18.1609, 7:00 a.m. (detail from fig. 12).

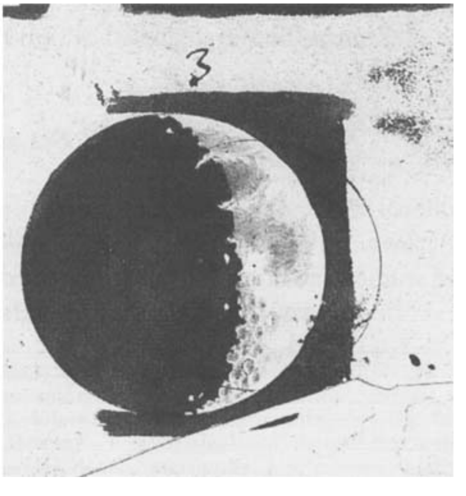

Figure 18. Lunar phase from 12.02.1609, 5:00 p.m. (detail from fig. 12).

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The finely graduated degrees of light cast over the face of the moon also serve to reveal the heights and depths of its surface. All the drawings are remarkable in the unprecedented plasticity Galileo lends to the sphere of the moon; the light plays over the irregular surface of the planet as in a film, illuminating the hills with its rays, while lower-lying regions still remain in the shadow of night. A study Galileo added to the lower right of the first moon sphere (fig. 13) demonstrates the depth effect of the light-dark contrast in an especially impressive way. In a section of the perspectively foreshortened lunar surface lies a deep crater, its dark blackness establishing a sharp contrast. The accentuation of shadow serves to create the impression of great depth. The deliberations Galileo and other astronomers had undertaken at this time, to determine the heights and depths of the moon's surface from the shadows cast on it, are here confirmed in a virtuosic modeling, constructed from the effects of light and shadow alone. The same effect, here illustrated in a single crater, characterizes all the moon drawings; the lower zone of the sixth sphere, for example, offers a three-dimensional planetary landscape of craters and mountains.

Galileo used the precision of his literary training,[43] as well, to capture in words the celestial theater of light and shadow opening up before his eyes:

> But not only does one see that the boundary between light and darkness on the moon is irregular and sinuous, but rather, what is even more amazing, there appears within the dark part of the moon a multitude of points of light completely divided and torn away from the illuminated zone and separated from it by a not inconsiderable interval. When one waits a while, they gradually increase in size and luminosity, until after two or three hours they join with the rest of the lighted part which has now become larger. Meanwhile, however, new points are continually set alight within the darkened part; sprouting upward, as it were, they grow and join themselves at last to the same illuminated surface that has extended itself still further.[44]

V. Eye and Hand

Galileo's stupendous achievement becomes especially apparent when compared with the work of the English natural scientist and cartographer Thomas Harriot, who studied the moon a number of weeks before Galileo with the help of a Dutch telescope with six-fold magnification. Harriot's drawing shows only an indistinct,

[43] On Galileo's literary capacity, recently: (Dietz Moss 1993, 76ss.).

[44] "Verum, non modo tenebrarum et luminis confinia in Luna inaequalia ac sinuosa cernuntur; sed, quod maiorem infert admirationem, permultae apparent lucidae cuspides intra tenebrosam Lunae partem, omnino ab illuminata plaga divisae et avulsae, ab eaque non per exiguam intercapedinem dissitae; quae paulatim, aliqua interiecta mora, magnitudine et lumine augentur, post vero secundam horam aut tertiam reliquae parti lucidae et ampliori iam factae iunguntur; interim tamen aliae atque aliae, hinc inde quasi pullulantes, intra tenebrosam partem accenduntur, augentur, ac demum eidem luminosae superficiei, magis adhuc extensae, copulantur" (Galileo 1610, 64; cf. Mann 1987, 56).

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crooked figure on the illuminated sphere (fig. 19). The boundary between light and shadow appears as an unsteady line, but the amplitudes of the indentations are not pronounced enough to suggest elevations and troughs.

Two-and-a-half moon phases after Harriot, however, Galileo recognized immediately that the patterns of light and shadow on the moon had to do with its irregular surface. In view of the fact that Galileo was able to reproduce this lunar theater of light in both words and drawings, the question arises as to why Harriot did not likewise manage to capture what Galileo comprehended shortly after him. It has been suggested that Galileo was able to recognize what remained hidden from Harriot simply because Harriot's telescope was of lesser quality.[45] Galileo's telescopes were indeed better than Harriot's Dutch one,[46] but the problem can by no means be limited to the difference in technical equipment. In comparison with Harriot's poor drawing even the pictures of the moon painted with unarmed eyes by Jan van Eyck[47] and Leonardo[48] are of higher quality. William Lower, a scientific associate of Harriot, wrote in a letter of June 1610 to Harriot about his inability to see correctly when being undermined by a limiting theoretical frame-

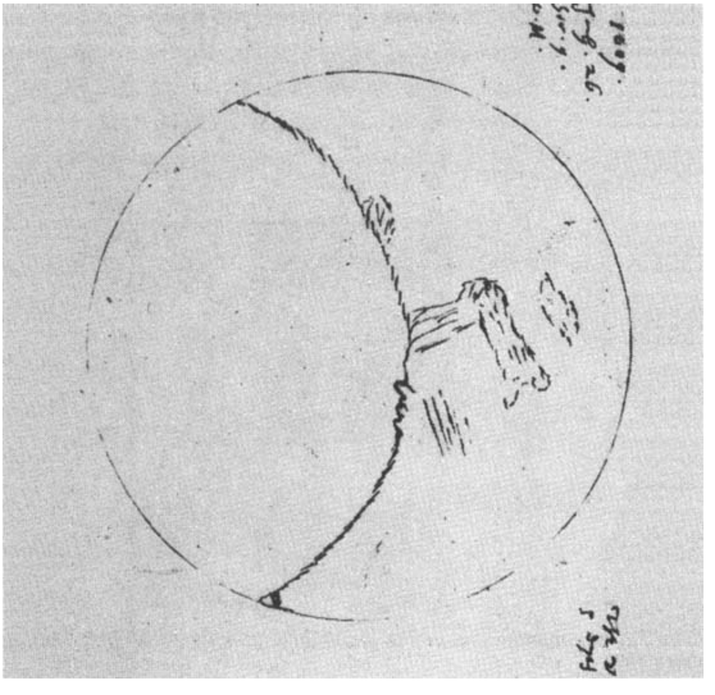

Figure 19. Thomas Harriot, lunar phase, drawing, Petworth mss. Leconsfield HMC 241/ix, fol. 26.

[45] Mann 1987, 59 n. 20.

[46] (Van Helden 1977, 26f.; van Helden 1984, 155). The early history of the invention of the telescope from the end of the sixteenth century up to Galileo has been clarified at the same time once again by Isabelle Pantin (Pantin 1992, IX–XXII and Hallyn 1992, 14–25).

[47] Montgomery 1994.

[48] Reaves 1987.

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work. As if reflecting on Harriot's shortcomings, Lower confessed that when observing the "Seven Sisters" or Pleiades, he did see eight stars, but did not dare to trust what he saw: "because I was prejugd with that number, I beleved not myne eyes."[49] There was a gap between what was seen and what was perceived. Harriot, we can conclude, was limited not only by his lenses or eyes, but also by his unwillingness in seeing beyond his theoretical horizon.

For Galileo, on the other hand, the problem posed by the surface of the moon was not a new one. Since his time with Cigoli in Florence, Galileo had been confronted with the theory of "secondary light," by which the effect of bright light is reflected as an ashy shine on another surface. Thus the ashy light on the dark surface of the moon could be explained in this manner.[50] Further, the question why Galileo revived Plutarch's opinion that the moon's surface contained mountains and valleys[51] instead of confirming Averroes' theory that different densities of the smooth body of the moon created the effects of light and darkness,[52] can be explained through the lessons Galileo took out of the lectures of Ostilio Ricci. Ricci taught not only the fundamentals of geometry, Euclid and Archimedes, but also perspective, and among the texts used were the *Ludi Matematici* of Leon Battista Alberti.[53] With their sections on the mensuration and perspective representation of objects, they constituted a part of the mathematical training of the artist at that time. The virtuosity with which this perspective theory was able to calculate and visualize surface configurations can be seen in the forms, impressive even today, shown in Wenzel Jamnitzer's *Perspectiva corporum* (fig. 20).[54] These

Figure 20. Wenzel Jamnitzer, stereometric body, copper engraving in: *Perspectica Corporum Regularum* (Nuremberg 1568).

[49] Quoted in Stevens 1900, 116; cf. Bloom 1978, 121.
[50] On the whole question of the "secondary light": (Reeves 1997, 8ss., 29ss.)
[51] On Plutrach as a source for the *Sidereus Nuncius*: (Casini 1994 and Montgomery 1996, 221f.)
[52] Ariew 1984.
[53] One of Ricci's Alberti-manuscripts is to be found among the Mss. Galileiani of the Biblioteca Nazionale Centrale in Florence (Ms.10, fol.1^r–16^r; cf. Settle 1971).
[54] Nuremberg, 1568.

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figures make clear that when Galileo observed the surface of the moon through his telescope, he recognized, in the form of a planet, a problem from the basic mathematics course for artists. He was able to grasp the patterns of light and shadow on a sphere as a function of height and depth configurations. His horizon of artistic experience enabled him to render what he saw.[55]

But for all Galileo's reliance on his sense of sight,[56] he was nonetheless faced with the painful realization that his foes likewise placed their trust in their eyes. Again and again the telescope had beguiled its untrained users with mirages and deceptions. Often, for example, the earliest telescopes had produced quadratic stars that too obviously contradicted the naked eye to be taken seriously.[57] In addition, the incontrovertible objection was advanced — to which Galileo responded with enraged invective — that whoever depended on the telescope was no longer the lord of his own sense of sight. When something previously unknown was observed with the help of the telescope, it was only a matter of time until an improved or entirely new piece of equipment would confront the eye with a different reality.[58] The epistemological value of the telescopic image was thus called into question.

In view of the doubt as to the fidelity of telescopic images, the question arises as to whether Galileo's drawings were not intended to supply the power of proof denied to the telescope itself. With the help of disegno, the celestial image was transferred to a medium that corresponded to familiar visual experience and remained verifiable day or night. The drawing fulfilled ideally what the heavens could only provide in measure, and this media shift may have played a role when Galileo, in context of his drawings of sun spots, spoke of the "giudizio finale," the "Final Judgment" of the Aristotelians.[59] His statement refers directly to the sunspots; the drawings, however, are the medium and the weapon of the "final judgment." If Galileo's first phase of moon observation was empirically demonstrable, then above all in the medium of drawing.

In an almost clairvoyant way, Galileo's painter friend Cigoli affirmed the interaction of perception and drawing. When he opposed Christopher Clavius' critique of Galileo's moon observations, he found an ironic excuse in the fact that

[55] Edgerton 1984, 226; cf. Hallyn 1992, 55–59; Holton 1996, 185ss.

[56] Winkler 1992, 195. Winkler and Van Helden limit Galileo's trust in visual representations to the years 1610–1613. Even if so, the fundamental fact remains that it was due to Galileo's artistic experience that on the long run "astronomy became a visual science" (Winkler 1992, 195, 217; cf. the implicit critique of Winkler and Van Helden by Montgomery: Montgomery 1996, 226): "For Galilei, the image must convey its own language, apart from words."

[57] Feyerabend 1993, 148f. and van Helden 1994, 11–15.

[58] Kutschmann 1986, 149f.

[59] "Intanto gli mando alcuni disegni delle macchie solari, fatti con somma giustezza tanto circa al numero quanto alla grandezza, figura e situazione di esse di giorno i giorno nel disco solare. Se occorrerà a V.S.Ill.ma trattare di questa mia resoluzione con i litterati di cotesta città, haverò per grazia il sentire alcuna cosa de i loro pareri, et in particolare de i filosofi Paripatetici, poi che questa novità pare il giudizio finale della loro filosofia." Galileo to Maffeo Barberini, June 2, 1612 (Galilei 1890–1909, 6:304–11, [306, 311]). I follow Montgomery's interpretation of the moon drawings as a "proof," "seemingly peeled from the eye, stolen and saved from the act of perception" (Montgomery 1996, 229, 284n.13).

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he could not draw, and thus was "not only half a mathematician, but a man lacking eyes as well."[60] This astounding statement presupposes that an adequate comprehension of reality involves not only its reception, but also its reproduction; not only its perception, but its construction as well. For Cigoli, Galileo could see better, because he was better prepared by his artistic training and knew how to draw. In an autodidactic process taking place between hand and eye, Galileo was better able to attain knowledge, both because he had learned to perceive the unusual and because he could demonstrate it in the medium of drawing.

Four years after Galileo's moon drawings, the list of names entering and leaving the art academy of Florence shows the following entry: "Galileo [son] of Vincenzo Galilei [has] to pay ten soldi on October 18, 1613, on account of his entrance into the academy, because the above-named has attained membership in the academy."[61] Non-artists, of course, were accepted into the academy. But Galileo was presumingly not only flattered with this appointment, but also confirmed in the methodological credo he had developed in his youth.

VI. The Empirical and Projection

There remains an irritating, irresolvable problem, which is still deserving of at least one thesis. Galileo's drawings served as the basis for four engravings, which were included in the 1610 first edition of *Sidereus Nuncius*. Because the fifth is essentially a duplicate of the third, there are only four distinct phases of the moon. They show peculiarities, which refer to the fundamental epistemological question, whether or not the belief in the interplay of perception and drawing, through consummate power of recognition, led to a strange interaction of strict empiricism, thoughtful propaganda and unwilling autosuggestion.

Two of the engravings are clear. The first shows, in accordance with the first drawing (fig. 13), the waxing moon of November 30, 1609 between 6:00 and 8:00 p.m. (fig. 21).[62] The fourth engraving depicts the waning moon (fig. 22),[63] and with its mountainous ring resembles the fourth drawing (fig. 16). Yet the middle two engravings are riddles. One of them (fig. 23),[64] shows the waxing half-moon of December 3, 1609 at 5:00 p.m. The oddity of this representation lies in the fact that while it also gives the mountain ring around the Mare Imbrium, it also shows an

[60] "Ora io ci ò pensato et ripensato, nè ci trovo altro ripiegho in sua difesa, se non che un matematico, sia grande quanto si vole, trovandosi senza disegnio, sia non solo un mezzo matematico, ma ancho uno huomo senza ochi." Cigoli, letter to Galileo, August 11, 1611 (Galilei 1890–1909, 11:168; cf. Edgerto 1991, 253n.41; Hallyn 1992, 58). The context of Cigoli's letter is studied by James M. Lattis in (Lattis 1994, 195ss.).

[61] "Galileo di Vinc:o Galilei de dare addi 18 di ottobre 1613 soldi 10 per sua ent[ra]ta nel Achedemia che detto disu vinto Achademico" (Florence, Archivio di Stato, Mss, Accademia del disegno No. 124, "Libro dell'Entrata e Uscita," fol. 52^v; cf. Chappel 1975, 91n.4).

[62] Galilei 1610, 8^r.

[63] Ibid., 10^v.

[64] Ibid., 9^v.

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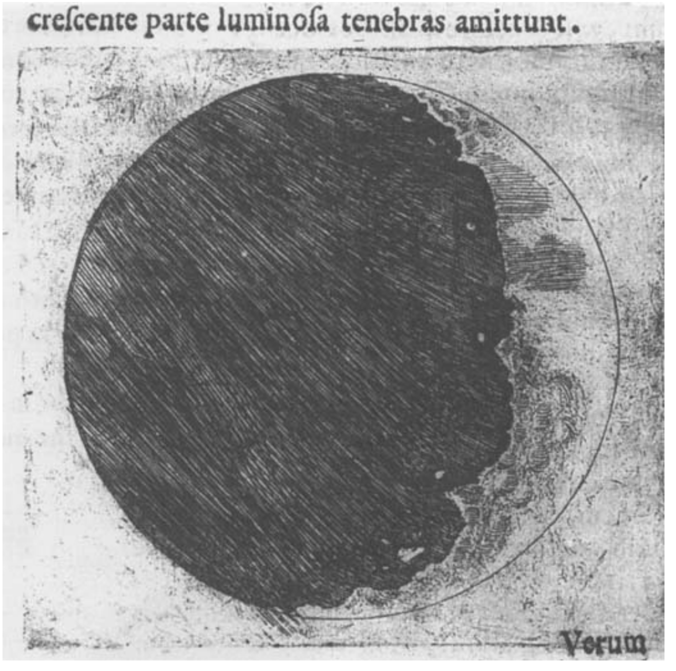

Figure 21. Galileo Galilei, lunar phase, copper engraving, in: *Sidereus Nuncius* (Venice 1610), p. 8r.

Figure 22. Galileo Galilei, lunar phase, copper engraving, in: *Sidereus Nuncius* (Venice 1610), p. 10v.

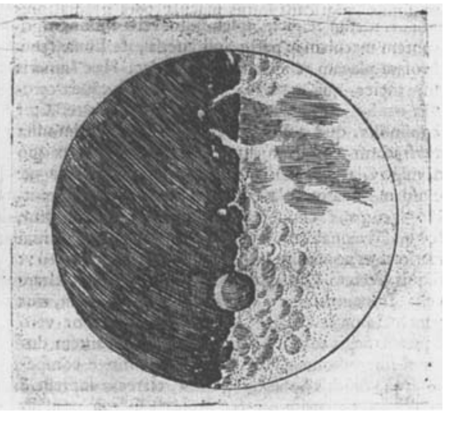

Figure 23. Anonymous, lunar surface, copper engraving, in: *Sidereus Nuncius* (Venice 1610), p. 9v.

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immense crater in the middle of the lower half. However, in the drawing, recorded a day earlier, there is not even the slightest suggestion of the existence of this crater.

The crater reappears in the next engraving of the waning half-moon (fig. 24)[65] in the same position, but lit from the opposite side. Again, there is no counterpart in the drawings. Obviously, Galileo wanted to demonstrate that the great ring of the crater is only visible exactly in the half-moon stages. In this way it sits exactly in the center, thus becoming a sort of trademark. In text, Galileo described it with the emphatic tone of a revelation: "There is another thing I am unable to suppress, as I noted it with admiration: almost in the moon's center there exists a cavity, larger than all the others, whose form is entirely round. I observed it both near the first and the last quarter and have attempted to render it as accurately as possible in the second, upper drawing."[66]

The problem is, this crater does not exist; neither in reality, nor in the drawing. Galileo's illumined crescent corresponds to the appearance of the moon down to

Figure 24. Anonymous, lunar surface, copper engraving, in: *Sidereus Nuncius* (Venice 1610), p. 10r.

[65] Ibid., 10^r. and 10^v.

[66] "Unum quoque oblivioni minime tradam, quod non nisi aliqua cum admiratione adnotavi: medium quasi Lunae locum a cavitate quadam occupatum esse reliquis omnibus maiori, ac figura perfectae rotunditatis; hanc prope quadraturas ambas conspexi, eandemque in secundis supra positis figuris quantum licuit imitatus sum" (Galilei 1610, 67f.).

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the finest details. Yet, there is no match for his large crater. One suspicion reasons that Galileo, through an act of autosuggestion or "good pedagogy" which wanted to make his point clear, enlarged one of the largest craters, the Albategnius, to such an extent, that its great, perfect roundness prominently occupied the central axis of the half-moon.[67]

An even more probable reason, as so often with Galileo, could lie in the elastic attention he afforded the perturbation which his discoveries must have fomented in many of his contemporaries. The crater would thus have served as a visual pendant to the exoteric rejection of Copernicanism. Galileo must have been cognizant that his lunar observations defied everything associated with the planet: as a round, harmonious, smooth form, a consummate sphere and celestial guarantee of platonic perfection. Yet, if Galileo was able to find a circular crater, which was positioned exactly on the central light axis of the half-moon, then the scandal must have been less acute. Though the moon was proven to be three-dimensional, it maintained its essential motif in a relatively central location, that is, the full circle; not as a real circle, but as a symbol of circular form.[68] Thus the moon was reinvested with the platonic dignity in the medium which had initially destroyed it: the irregularity of its surface.

This circle was perhaps one of the reasons for Galileo's success. In Harriot's second (17 July 1610) sketch of the moon (fig. 25), the characteristic craters

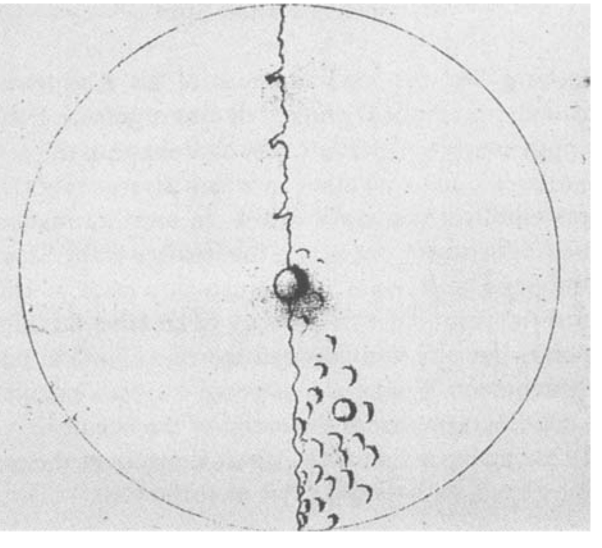

Figure 25. Thomas Harriot, lunar phase, drawing, Petworth mss. Leconsfield HMC 24/ lix, fol. 20.

[67] (Gingerich 1975, 85; cf. the comparison in Casini 1994, 57). The thesis that Galileo "exaggerated the size of what he had observed in order to bring out the salient features" was developed by Shea (Shea 1990, 56f.)

[68] Gingerich 1975, 86.

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appearing lower right, demonstrate that the British scientist had come to accept the moon's surface was not smooth, but scattered with mountains and hollows. Apparently, it was not only his own lunar observations, but the engravings in Galileo's publication, that prompted Harriot to see objectively.[69] Yet, his learning process was limited once again to what he learnt, and not what he saw. In accordance with Galileo's emphatical description, he set the fictional crater almost exactly in the center of the moon. His drawing bridges the gap between Galileo's text and Galileo's engraving, but is even further afield from reality than was Galileo's crater image. Thus, in this case, it was not observation of nature, but suggestion which won the contest of credibility.

Harriot was hardly an exception. In 1626, the Jesuit Mission in China used Galileo's telescope pictures to extol the superiority of the Christian science to the Chinese. One of the two engravings appears as a woodcut, turned upside-down, in the upper-left, and situates the imaginary crater on the line of equilibrium between lunar day and night.[70]

Galileo's images of the moon were as much a case for art history as for cognitive psychology; in other words, he not only saw what he was able to see, but also, what he wanted to see. Yet this realization would offer a hasty conclusion. There is an additional facet to the problem. Beyond Galileo's projection of a circle lies the disappearance of Kepler's ellipse.

VII. Einstein's Blind Spot

In 1925, Aby Warburg had the reading room of his Kulturwissenschaftliche Bibliothek topped with an elliptical dome.[71] It was a gesture honoring Kepler's discovery of the elliptical orbits of planets. The oval shape of the ceiling correlated with figure 3 of Warburg's pictorial atlas, in which diverse models of the cosmos lead up to Kepler's elliptical planetary orbits. In another instance, Warburg's exhibition "Picture Collections Concerning the History of the Study of and Belief in Stars at the Hamburg Planetarium" concluded with Kepler's ellipse.[72] With its two poles, it seemed to symbolize a bi-polarity of creative thinking: not circling around a single point, but oriented between the two elliptical poles of magical thinking and Enlightenment. Warburg considered Kepler's calculations a unique symbol of human self-liberation from the realm of the occult.[73]

In September 1928, during a visit with Albert Einstein at the seaside resort of Scharbeutz, Warburg tried, with the aid of his pictorial atlas, "to grant [Einstein] a

[69] Bloom 1978, 121; Edgerton 1984, 227.
[70] Edgerton 1991, 269f.
[71] Jesinghausen-Lauster 1985, 216; cf. von Stockhausen 1992, 37ss.; lastly with corrections, Settis 1996, 152.
[72] Warburg 1993, fig. XVII.
[73] Jesinghausen-Lauster 1985, 215f.; cf. von Stockhausen 1992, 37ss.

https://doi.org/10.1017/S0269889701000333 Published online by Cambridge University Press

glimpse of the soil in which his cosmological mathematics had originated." In a letter to Fritz Saxl, Warburg wrote later: "[Einstein] followed my pictures like a schoolboy at the movies...and (tested) the soundness of my conclusions by following up with merciless questioning. ... Only on Kepler and the ellipse, I believe, I did not get a passing grade. Otherwise he was satisfied with me."[74] In a thank-you note to Warburg, Einstein touched once more on the subject with the intent of absolving Kepler, writing that Kepler would have "been ashamed ... to earn his keep by playing such an unsophisticated game" — meaning astrological practices.[75]

Warburg was clearly unable to convince Einstein that his preoccupation with Kepler's ellipse had nothing to do with the evaluation of astrology, but instead concerned the aesthetic influence on scientific-cosmological thinking. In other words, the question whether stars move along a circle or an ellipse was not answered merely through observation and calculations, but also, and especially, through the aesthetic-visual pre-consciousness of the scientists.

Because Einstein was not prepared to accept this line of thinking, he was blinded to the problem's solution, a problem which has since become a thorn in the side of the history of science and which frustrated Einstein to the end of his life: namely, the question why Galileo rejected Kepler's 1605 publication *Nova Astronomia*. In 1953, in a mixture of puzzlement and displeasure, Einstein stated: "That this decisive advancement left no traces in Galileo's life work is a grotesque illustration that creative human beings frequently lack a receptive frame of mind."[76]

Erwin Panofsky, in Hamburg as one of those privileged scholars to have researched under the Warburg Library ellipse, was especially sensitive to such remarks.[77] Shortly after Einstein, Panofsky was awarded a place at the Institute for Advanced Studies in Princeton. In direct proximity to Einstein for almost twenty years, Einstein's remark inspired Panofsky to examine Galileo's motive for rejecting Kepler's *Nova Astronomia* and to bridge, as it were, the gap between the histories of physics and art.[78] The following year, Panofsky published his "Galileo as a Critic of the Arts" as a response to Einstein's query.[79]

Panofsky tried to demonstrate that the reasons for Galileo's disregard of *Nova*

[74] Einstein followed "gespannt wie ein Schuljunge im Kino meinen Bildern (...) und (prüfte) unter steten unerbittlichen Nachfragen die Stichhaltigkeit meiner Schlüsse (...). Nur bei Kepler und der Ellipse habe ich, glaube ich, nicht gut bestanden; sonst war er mit mir zufrieden" Aby Warburg to Fritz Saxl, September 5, 1928 in (Warburg 1928). This letter and the one in the following note were made available through the courtesy of Claudia Naber.

[75] Kepler would have felt ashamed "sich sein Futter durch ein so plumpes Spiel zu verdienen." (Albert Einstein to Aby Warburg, September 10, 1928, Warburg 1928). It may be surmised that Einstein was not only discomforted by Warburg's identification with Kepler, but also by his portrayal of Kepler as wrestling with astrology and magic.

[76] Einstein 1953, xvi.

[77] On the occasion of the Nobel Prize awards ceremony for his friend, the mathematician Wolfgang Pauli, in December 1945, Panofsky held one of the laudatory speeches, in which he longingly recalled those times when models of the cosmos, like Kepler's still possessed "meaning." Cited from (Ludwig 1974, 115f.).

[78] Panofsky 1954, 23f.

[79] Ibid., 24.

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Astronomia were not only to be found in the close fields of physics and mathematics, but instead in a wider concept of world-view within which aesthetical values played a role as important as these. Galileo was opposed to Mannerism with its clever, trompe l'oeil, anarchic aesthetic, which had been dominating the European art world for half a century. Like his artist friends, he had had enough of this artistic direction. His affections and aversions within the arts were localized around the two poets Ludovico Ariosto and Torquato Tasso. Galileo celebrated the Rennaissance literatus Ariost as the epitome of the poetic arts, while heaping scathing criticism upon Tasso. The reasons for his rejection are art historically revealing. Galileo attacked Tasso's "distorted" verse, comparing it to anamorphosis whose meaning becomes "visible and accessible at an angle" and "which obstructs the gaze by extravagant means through a collection of fantastic, chimerical and superfluous illusions."[80]

Galileo's anti-Mannerist notion of art evoked a feeling of repulsion beyond all reason. Panofsky argued that to Galileo's sense of harmony, inextricably wedded to the movement of circles, Kepler's conclusions appeared unpalatable, even monstrous, much like anamorphosis, and that such aesthetic sensibilities created an insurmountable barrier in his mind with regard to celestial mechanics. According to Panofsky, Galileo was only capable of envisioning a harmonious cosmos based on circles, so that Kepler's compressed elliptical orbits appeared as unbearable aesthetic deformations, as though Tasso's oblique verse and anamorphosis were projected onto heaven.

This trial of understanding Galileo's silence about Kepler's elliptical orbits was appraised by Alexandre Koyrè,[81] reprinted in a revised form in *Isis* and further discussed in the history of science and art history,[82] but it must have been a great disappointment for Panofsky that Einstein ignored it. Although Einstein discussed the problem again in his last interview, in 1955, he took no account of Panofsky's conclusions.[83] Like Warburg 25 years earlier, Panofsky failed to convince Einstein of the aesthetic consequences of Kepler's elliptical orbits.

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[80] "E farassi una di quelle pitture, le quali, perchè riguardate in scorcio da un luogo determinato mostrino una figura umana, sono con tal regola di prospettiva delineate, che, vedute in faccia e come naturalmente e comunemente si guardano le altre pitture, altro non rappresentano che una confusa e inordinata mescolanza di linee e di colori, dalla quale anco si potriano malamente raccapezare imagini di fiumi e sentier tortuosi, ignude spiaggiae, nugoli o stranissime chimere. (...) tanto nella poetica finzione è piu degno di biasimo che a favola corrente, scoperta e prima dirittamente veduta, sia per accomodarsi alla allegoria, obliquamente vista e sottointesa, stravagantamente ingombrata di chimere e fantastiche e superflue imaginazioni" in "Considerazioni al Tasso" (Galilei 1890–1909, IX:59–148 [129f.]).

[81] Koyrè 1955.

[82] Panofsky March 1956; Rosen March 1956; Panofsky June 1956; Fehl, 1958; Lotz 1958; Mazzi 1985; Shea 1985; Puppi 1995, 244ss.; Reeves 1997, 6f., 18ss.

[83] Cohen July 1955, 69; cf. Fölsing 1993, 243.

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It was the draftsman Galileo, who was first able to recognize and record the surface of the moon. It was also the artist Galileo, who manipulated the surface of the moon into, as Hans Blumenberg described, "an interplay of revealment and veiling"[84] thereby separating it from Kepler's planetary orbits.

Yet, regardless of this condition, there persist the irresolvable epistemological questions precipitated by Galileo's disclosures. If the case of Galileo the "artist" can be generalized, then to the extent that there are art historical inquiries, whose answers would be impossible without the history of natural sciences. Just as the other way around, there are scientific complexes which remain impenetrable, as long as the visual structures of human thought, indispensable in their illumination and obscuring, are ignored.

In any event, Viviani ought to have linked not Michelangelo, but Leonardo da Vinci with Galileo. For it was Leonardo, the outstanding researcher of the natural world and occasional painter, who corresponded in a reciprocal manner to Galileo, the Medici court artist, who, by the way, worked as a researcher.

References

Ariew, Roger. 1984. "Galileo's Lunar Observations in the Context of Medieval Lunar Theory." *Studies in History and Philosophy of Science* 15:221ss.

Biagioli, Mario. 1993. *Galileo, Courtier. The Practise of Science in the Culture of Absolutism*. Chicago and London: Univ. of Chicago Press.

Bloom, Terrie F. 1978. "Borrowed Perceptions: Harriot's Maps of the Moon." *Journal for the History of Astronomy* 9:117–122.

Blumenberg, Hans. 1980. "Das Fernrohr und die Ohnmacht der Wahrheit." In *Galileo Galilei, Sidereus Nuncius [Nachricht von neuen Sternen]. Dialog über die Weltsysteme (Auswahl). Vermessungen der Hölle Dantes. Marginalien zu Tasso*, 7–75, edited by Hans Blumenberg. Frankfurt am Main, Suhrkamp.

Bredekamp, Horst. 1993. *Florentiner Fußball. Die Renaissance der Spiele. Calcio als Fest der Medici*. Frankfurt am Main and New York: Campus-Verlag.

——. 1995. "Words, Images, Ellipses." In *Meaning in the Visual Arts: Views from the Outside. A Centennial Commemoration of Erwin Panofsky (1892–1968)*, edited by Irving Lavin, 363–371. Princeton.

——. 1996a. "Galileo Galilei als Künstler." In *Übergangsbogen and Überhöhungensrampe — naturwissenschaftliche und künstlerische Verfahren. Symposium I und II*, edited by Bogomir Ecker and Bettina Sefkow, 54–63. Hamburg.

——. 1996b. "Zwei frühe Skizzenblätter Galileo Galileis." In *Ars naturam adiuvans. Festschrift für Matthias Winner zum 11. März 1996*, edited by Victoria von Fleming and Sebastian Schütze, 477–484. Mainz am Rhein.

[84] Blumenberg 1980, 48.

https://doi.org/10.1017/S0269889701000333 Published online by Cambridge University Press

Callot, Jacques. 1971 [1592–1635]. *Das gesamte Werk*, edited by Thomas Schröder. Munich: Rogner und Bernhard.
Casini, Paolo. 1994. "Il 'Dialogo' di Galileo e la Luna di Plutarcho." In *Novità Celesti e Crisi del Sapere. Atti del Convegno Intternazionale di Studi Galileiani*, edited by Paolo Galluzzi, 57–62. Florenz.
Cavina, Anna Ottani. March 1976. "On the Theme of Landscape-II: Elsheimer and Galileo." *The Burlington Magazine* 118/876:139–144.
Chappel, Miles. 1975. "Cigoli, Galileo, and Invidia." *Art Bulletin* 57/1:91–98.
Ciampoli, Giovanni. 1978. "Discorso sopra la Corte di Roma." In Marziano Guglielminetti and Mariarosa Masoero, *Lettere e prose inedite [o parzialmente edite] di Giovanni Ciampoli. Studi secenteschi* 19:228–237.
Cohen, Bernard. July 1955. "An Interview with Einstein." *Scientific American* 93:69–73.
Contini, R. 1991. *Il Cigoli.* Soncino.
de Angelis, Paolo. (1621) imprimatur 1616. *Basilicae S. Marioris de Urbe...descriptio et delineatio.* Rome.
de Maio, Romeo. 1978. *Michelangelo e la Controriforma.* Rome and Bari.
de'Nelli, Giovanni Battista Clemente. 1793. *Vita e commercio letterario di Galileo Galilei.* Lausanne.
Dietz Moss, Jean. 1993. *Novelties in the Heavens. Rhetoric and Science in the Copernican Controversy.* Chicago and London.
Drake, Stillman. 1976. "Galileo's First Telescopic Observations." *Journal for the History of Astronomy* 7:153–168.
Dussler, Luitpold 1959. *Die Zeichnungen des Michelangelo. Kritischer Katalog.* Berlin.
Edgerton, Samuel Y. 1984. "Galileo, Florentine 'Disegno' and the 'Strange Spottedness' of the Moon." *Art Journal* 44/1:225–32.
——. 1991. *The Heritage of Giotto's Geometry.* Ithaca and London.
Einstein, Albert. 1953. "Introduction" to Galileo Galilei. In *Dialogue Concerning the Two Chief World Systems.* Translated by Stillman Drake. Berkeley.
Faranda, Franco. 1986. *Ludovico Cardi detto il Cigoli.* Rome.
Favaro, Antonio. 1880. "Inedita Galilaeiana. Frammenti tratti dalla Biblioteca Nazionale di Firenze." *Atti e Memorie dell'Instituto Veneto di Scienze, Lettere ed Arti* 21:35–43.
——. 1887. "Sul giorno della nascità di Galileo." *Memorie del R. Istituto Veneto di scienze lettere ed arti* 22:703–711.
Fehl, Philipp. 1958. "Review." *Journal of Aethetics and Art Criticism* 17:124–125.
Feldhay, Rivka. 1995. *Galileo and the Church: Political Inquisition or Critical Dialogue?* Cambridge.
Feyerabend, Paul. 1993. *Wider den Methodenzwang*, 4th ed. Frankfurt am Main: Suhrkamp.
Fölsing, Albrecht. 1993. *Albert Einstein. Eine Biographie.* Frankfurt am Main: Suhrkamp.

https://doi.org/10.1017/S0269889701000333 Published online by Cambridge University Press

Frieß, Peter. 1993. *Kunst und Maschine. 500 Jahre Maschinenlinien in Bild und Skulptur*. Munich: Dt. Kunstverl.

Galilei, Galileo. 1890–1909. *Le Opere.di Galileo Galilei*. Edizione Nazionale, edited by Antonio Favaro, 20 vols. Florence: Barbèra Editrice. Reprint: 1929–1939, 1964–1966, 1968.

—. 1610. *Sidereus Nuncius*. In *Opere di Galileo* by Galilei, Galileo (1890–1909), 3/1:53–96. Florence: Barbèra Editrice.

Galluzzi, Paolo. 1994. "I Sepolcri di Galileo: o delle spoglie 'vive' di un eroe della scienza." Lecture delivered at the symposium *Galileo Galilei*. Berlin: Istituto di Cultura di Berlino.

Garrard, Mary D. 1989. *Artemisia Gentileschi. The Image of the Female Hero in Italian Baroque Art*. Princeton, New Jersey: Princeton University Press.

Gingerich, Owen. 1975. "Dissertation cum Professore Righini et Siderio Nuncio." In *Reason, Experiment, and Mysticism in the Scientific Revolution*, edited by M. L. Righini Bonelli and William R. Shea, 77–88. New York.

Hallyn, Fernand. 1992. "Introduction." In Galileo Galilei, *Le Messager des étoiles*, 14–101. Paris.

Haskell, Francis and Nicholas Penny. 1981. *Taste and the Antique: The Lure of Classical Sculpture 1500–1900*. New Haven and London.

Heikamp, Detlev. 1978. "Ammannati's Fountain for the Sala Grande of the Palazzo Vecchio in Florence." In *Dumbarton Oaks Colloquium on the History of Landscape Architecture* V, 116–176, edited by Elisabeth B. MacDougall. Washington/D.C.

Holton, Gerald. 1996. "On the Art of Scientific Imagination." *Daedalus* 125/2:183–208.

Jesinghausen-Lauster, Martin. 1985. *Die Suche nach der symbolischen Form. Der Kreis um die kulturwissenschaftliche Bibliothek Warburg*. Baden-Baden: Verlag V. Koerner.

Kant, Max Immanuel. 1923. "Entwürfe zu dem Colleg über Anthropologie aus den 70er und 80er Jahren." In *Kant's gesammelte Schriften*, edited by Königlich Preußische Akademie der Wissenschaften, 15:655–899. Berlin and Leipzig.

Kemp, Wolfgang. 1979. *". . . einen wahrhaft bildenden Zeichenunterricht überall einzuführen" Zeichnen und Zeichenunterricht der Laien. 1500–1870. Ein Handbuch*. Frankfurt am Main.

Koyrè, Alexandre. 1955. "Attitude esthetique et pensée scientique." *Critique*, nos. 100–101, 835–847. Printed in German in Alexander Koyrè. 1988. "Kunst und Wissenschaft im Denken Galileis." In *Galilei. Die Anfänge der neuzeitlichen Wissenschaft*, 70–83. Berlin; reprinted with Panofsky's text in Erwin Panofsky. 1993. *Galilée Critique d'Art*, edited and translated by Nathalie Heinich, 81–97. Leuven.

Kutschmann, Werner. 1986. *Der Naturwissenschaftler und sein Körper*. Frankfurt am Main.

Lattis, James M. 1994. *Between Copernicus and Galileo. Christoph Clavius and the Collapse of the Ptolemaic System*. Chicago and London.

https://doi.org/10.1017/S0269889701000333 Published online by Cambridge University Press

Lotz, Wolfgang. 1958. "Review." *Art Bulletin* 40/2:162–164.

Ludwig, Richard M. 1974. *Dr. Panofsky and Mr. Tarkington. An Exchange of Letters*. Princeton.

Magani, Fabrizio. 1995. "Il Collezionismo a Venezia al Tempo del Soggiorno di Galileo." In *Galileo Galilei e la Cultura Veneziana, Atti del Convegno di Studio Promosso nell' Ambito delle Celebrazioni Galileiane indette dall' Università degli Studi di Padova* (1592–1992), 1992. 137–159. Venice: Lettere ed Arti.

Mann, Heinz Herbert. 1987. "Die Plastizität des Mondes — Zu Galileo Galilei und Ludovico Cigoli." In *Natur und Kunst*, edited by Götz Pochat and Brigitte Wagner. (*Kunsthistorisches Jahrbuch Graz*, no. 23,55–59).

Masotti, Arnaldo. 1970–1980. "Ricci, Ostilio." In *Dictionary of Scientific Biography*, XI:405f., edited by Charles C. Gillispie, 16 vols. New York.

Matteoli, Anna. 1980. *Lodovico Cardi Cigoli. Pittore e Architetto*. Pisa.

—. 1992. *Disegni di Lodovico Cigoli* (1559–1613), exh. cat. Florence: Uffizi.

Mazzi, Maria Cecilia. 1985. "Introduzione." In Erwin Panofsky, *Galileo Critico delle Arti*, 7–18. Venedig.

Montgomery, Scott L. 1994. "The First Naturalistic Drawings of the Moon: Jan van Eyck and the Art of Observation." *Journal for the History of Astronomy* 25:317–320.

—. 1996. *The Scientific Voice*. New York.

Mss. Accademia del disegno No. 124. Archivio di Stato, Florence.

Mss. Galileiani. Biblioteca Nazionale Centrale. Florence.

Olschki, Leonardo. 1965 [1922]. *Bildung und Wissenschaft im Zeitalter der Renaissance in Italien*, 3:141–155, *Galilei und seine Zeit*. Vaduz.

Ostrow, Steven F. 1996a. *Art and Spirituality in Counter-Reformation Rome. The Sistine and Pauline Chapels in S. Maria Maggiore*. Cambridge.

—. 1996b. "Cigoli's Immacolata and Galileo's Moon: Astronomy and the Virgin in Early Seicento Rome." *Art Bulletin* 78/2:218–235.

Panofsky, Erwin. 1954. *Galileo as a Critic of the Arts*. The Hague.

—. March 1956. "Galileo as a Critic of the Arts." *Isis* 47/147:3–15.

—. June 1956. "More on Galileo and the Arts." *Isis* 47/148:182–185.

Pantin, Isabelle. 1992. "Introduction." In *Sidereus Nuncius* by Galileo Galilei (1610). Le Messager Celeste, pp. IX–CIV. Paris.

Perrig, Alexander. 1991. *Michelangelo's Drawings: The Science of Attribution*. New Haven and London.

Puppi, Lionello. 1995. "Galileo Galilei e la Cultura Artistica a Venezia tra la Fine del 500 e l'Inizio del '600." In *Galileo Galilei e la Cultura Veneziana, Atti del Convegno di Studio Promosso nell' Ambito delle Celebrazioni Galileiane indette dall' Università degli Studi di Padova* (1592–1992), 1992. 243–255. Venice: Lettere ed Arti.

Reaves, Gibson and Carlo Pedretti. 1987. "Leonardo da Vinci's Drawings of the Surface of the Surface Features of the Moon." *Journal for the History of Astronomy* 18/52:55–58.

https://doi.org/10.1017/S0269889701000333 Published online by Cambridge University Press

Reeves, Eileen. 1997. *Painting the Heavens. Art and Science in the Age of Galileo.* Princeton: Princeton University Press.

Reti, Ladislao. 1959. "'Non si volta chi à stella è fisso'. Le 'imprese' di Leonardo da Vinci." In *Bibliothèque d'Humanisme et Renaissance* 21:7–54.

Reynolds, Ted. 1974. "The 'Accademia del Disegno' in Florence, Its Formation and Early Years, Ph.D. diss., Columbia University. New York.

Righini, Guglielmo. 1975. "New Light on Galileo's Observations." In *Reason, Experiment, and Mysticism in the Scientific Revolution*, edited by M. L. Righini Bonelli and William R. Shea, 59–76. New York.

——. 1978. *Contributo alla interpretazione scientifica dell' opera astronomica di Galileo.* Florence.

Rosen, Edward. March 1956. *Isis* 47/147:78–80.

Segre, Michael. 1989. "Viviani's Life of Galileo." *Isis* 80:207–31.

——. 1991. *In the Wake of Galileo.* New Brunswick/New Jersey.

Settis, Salvatore. 1996. "Warburg continuatus. Description d'une bibliothèque." In *Les Pouvoir des Bibliothèque. La mémoire des livres en Occident*, edited by Marc Baratin and Christian Jacob, 122–170. Paris.

Settle, Thomas B. 1971. *"Ostilio Ricci, a Bridge between Alberti and Galileo."* In *Actes du XIIe Congrès International d'Historie des Sciences*, Paris 1968, 3B:122–26. Paris.

Shea, William R. 1985. "Panofsky revisited: Galileo as a Critic of the Arts." In: *Renaissance Studies in Honor of Craigh Hugh Smyth*, edited by Andrew Morrogh et al., I:481–492. Florenz.

Shea, William S. 1990. "Galileo Galilei: An Astronomer at Work." In: *Nature, Experiment, and the Sciences. Essay on Galileo and the History of Science in Honour of Stillman Drake*, edited by Trevor H. Levere and William R. Shea, 51–76. Dordrecht.

Stevens, Henry. 1900. *Thomas Harriot, the mathematician, the philosopher and the scholar.* London.

Tabarroni, Giorgio. 1984. "I Disegni Autografi della Luna e Altre Espressioni Figurative dei Manoscritti Galileiani." In: *Novità Celesti e Crisi del Sapere. Atti del Convegno Internazionale di Studi Galileiani*, edited by Paolo Galluzzi, 51–55. Florence.

van Helden, Albert. 1977. "The Invention of the Telescope." *Transactions Of The American Philosophical Society Held At Philadelphia For Promoting Useful Knowledge* 67:part 4.

——. 1984. "Galileo and the Telescope." In *Novità Celesti e Crisi del Sapere. Atti del Convegno Internazionale di Studi Galileiani, edited by Paolo Galluzzi*, 149–158. Florence.

——. 1994. "Telescopes and Authority from Galileo to Cassini." In *Instruments*, edited by Albert van Helden and Thomas L. Hankins. =Osiris 9:9–29.

Vasari, Giorgio. 1962. *Vita di Michelangelo*, edited by Paola Barocchi. Milan and Naples.

https://doi.org/10.1017/S0269889701000333 Published online by Cambridge University Press

Viviani, Vincenzio. 1890–1909. “Racconto istorico della vita del Sig. Galileo Galilei”. In *Opere di Galileo* by Galilei Galileo, 19:597–646. Florence: Barbèra Editrice.

von Stockhausen, Tilmann. 1992. *Die kulturwissenschaftliche Bibliothek Warburg. Architektur, Einrichtung und Organisation.* Hamburg.

Warburg, Aby. 1928. *Warburgs Korrespondenzarchiv*, General Correspondence 1928, E. Warburg Institute, London.

Warburg, Aby M. 1993. *Bildersammlung zur Geschichte von Sternglaube und Sternkunde im Hamburger Planetarium*, edited by Uwe Fleckner et. al. Berlin.

Warnke, Martin. 1985. *Hofkünstler. Zur Vorgeschichte des modernen Künstlers.* Cologne.

Wazbinski, Zygmunt. 1987. *L'Accademia Medicea del Disegno a Firenze nel Cinquecento. Idea e Istituzione*, 2 vols. Florence.

Westfall, Richard. 1984. “Galileo and the Accademia dei Lincei.” In *Novità Celesti e Crisi del Sapere. Atti del Convegno Internazionale di Studi Galileiani*, edited by Paolo Galluzzi, 189–200. Florence.

Westfehling, Uwe. 1993. *Zeichnen in der Renaissance. Entwicklung / Techniken / Formen / Themen.* Cologne.

Whitaker, Ewan A. 1978. “Galileo's Lunar Observations and the Dating of the Composition of Sidereus Nuncius.” *Journal of the History of Astronomy* 9:155–69.

——. 1989. “Selenography in the Seventeenth Century.” In *The General History of Astronomy*, edited by Michael Hoskin, 2:119–42. *Planetary Astronomy from the Renaissance to the Rise of Astrophysics.* Cambridge

Winkler, Mary and Albert Van Helden. 1992. “Representing the Heavens: Galileo and Visual Astronomy.” *Isis* 83:195–217.

Wolf, Gerhard. 1991/92. “Regina Coeli, Facies Lunae, ‘Et in Terra Pax’. Aspekte der Ausstattung der Cappella Paolina in S. Maria Maggiore.” In *Römisches Jahrbuch der Bibliotheca Hertziana*, 27/28:284–336.

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