> indicate on these images all the details of the lunar surface, such as the islands and the mountain summits. Often distant from the continents, these features appear instantaneously while the moon is waning and disappear suddenly when it is waxing. They offer the best way for finding longitudes, and can be employed on almost any day.

Now we can appreciate the true breadth of Van Langren's cartographic project: he wanted to produce a veritable atlas of the moon, the published broadsheet being just a way to ascertain his priority in the attribution of names and, evidently, a gift he expected the king to reciprocate by offering support for the larger undertaking.

Van Langren was able to secure all the privileges he required from the Privy Council in Brussels. The inscription on the map ends with a clear threat: "By royal decree, all are forbidden to make any changes to the names on this figure, under penalty of indignity." No one paid attention to the prohibition, and all places on the moon were to be baptized anew not once, but twice over the next few years.

4 Time Concreted

The first maps of the moon that are specifically, unmistakably of the *moon* are the ones published by Johannes Hevelius in 1647. What is special about them is not that they are *of* the moon but the fact that they face the problem of time head-on, grabbing time and putting it on paper. The impermanence of the face of the moon is not swept aside, but, quite to the contrary, it is rendered concretely on map space itself. After analyzing the "Hevelian way," I discuss at some length an interesting sub-genre of lunar cartography, which is the eclipse map. Not only Hevelius's eclipse maps, but also Cassini's are discussed and shown to be functional, instrumental maps. Finally, I suggest viewing the figure who is invariably presented as Hevelius's selenographic nemesis, the Jesuit Giovanni Battista Riccioli, as a Hevelian at heart.

4.1 *Moonstruck by* Selenographia

Johannes Hevelius's *Selenographia: sive, Lunae Descriptio* appeared in 1647, in Gdansk. A massive in-folio tome, the book ran to some 500 densely printed pages in Latin. It was Hevelius's first book, and he took care of every aspect of the process of publication, acting as his own editor, draftsman, and engraver. Only printing was committed to a third party, but Hevelius paid for it, retaining full control of his debut in the Republic of Letters. Financing the print run was certainly not a problem for this wealthy brewer and soon-to-be city magistrate in his native Gdansk. Born there in 1611, Hevelius had spent the early 1630s studying and traveling in the Netherlands, England, and France (where he made the acquaintance of Gassendi). After returning to his hometown, Hevelius decided to build a private observatory on the roof of his own house.[21] Perhaps this self-reliance and the fact that astronomy was always circumscribed to Hevelius's domestic space help us understand why, unlike so many books of the time, *Selenographia* is not dedicated to anybody: Hevelius is at once the author, financial backer, protagonist, and guarantor of the work. Even Galileo, who adorns the allegorical frontispiece beside the Arab astronomer Ibn al-Haytham (Alhazen), symbolizing the importance of the senses for astronomy, is disparaged by Hevelius. The latter wonders that what he considers to be the appallingly low quality of the moon drawings in the *Sidereus Nuncius* can only be explained if Galileo was either a careless observer, was unskilled in draftsmanship, or had a very bad telescope (Hevelius 1647, 205). In fact, positioning himself as more careful and attentive to detail than Galileo is part of Hevelius's bid for his readers' trust.

Selenographia is at the same time a monument to observational astronomy and to the power of visual representation. It has 111 full-page figures, including three foldout maps, plus two-dozen illustrations embedded in the printed text, all of them copperplate engravings. With the exception of a handful, every image in the book was drawn and engraved by Hevelius himself, and he never loses an opportunity to remind the reader of this, from the "Author sculpsit" almost invariably inscribed on a corner of the illustrations to textual reiterations of his ultimate responsibility for the images and everything else in the book. The index includes precise instructions regarding the placement of the full-page figures, and Hevelius addresses bookbinders in order to provide details on how they must handle these sheets (Hevelius 1647, last page of index).

The importance of the printed image for Hevelius's endeavor in *Selenographia* and, far more importantly, to a far-reaching reconfiguration of early-modern astronomy as a whole was forcefully demonstrated by Mary G. Winkler and Albert van Helden. Against a received view of Hevelius as a dilettante, albeit talented astronomer who contributed nothing original to the field, Winkler and van Helden argue that he was responsible for nothing less than the establishment of a "visual language" that was bound to be almost immediately taken

21 Scholarship on Hevelius's life and work (of which *Selenographia* is but his first production) has been steadily growing over the last few years. I would recommend, as a most up-to-date starting point, the collection edited by Kremer and Włodarczyk (2013).

up by all practitioners of astronomy. This happened so quickly that the new visual language became thoroughly naturalized, to the point that its indebtedness to *Selenographia* was all but completely lost. In Winkler and Van Helden's words,

> [i]n the second half of the seventeenth century pictures of heavenly phenomena observed through the telescope became common, and these pictures spoke for themselves. In fact, they sometimes contained information that was not explained until much later. (…) Hevelius's authority flowed from his copious use of visual evidence whose reliability he was able to impress upon the reader. Yet, by the end of the century *Selenographia* was already obsolete. As others discovered that some of his observations were in error, the influence of Hevelius's work in telescopic astronomy waned, and by the time of his death it had been superseded. His method of visual communication had, however, by then become an accepted part of astronomy and science in general. Indeed, it had become so common that this achievement of Hevelius had become invisible.
>
> WINKLER AND VAN HELDEN 1993, 116

Contrary to what one might be tempted to believe from the remarkable success of the *Sidereus Nuncius*, up to the mid-seventeenth century, astronomy had almost no reliance on *depicting* celestial phenomena. Pictures, here narrowly understood as naturalistic renderings of observation, played close to no role in the communication of astronomical discoveries, in arguments in favor of their reality, or in reasoning about phenomena (Winkler and Van Helden 1992, note 2 and *passim*). Indeed, with the exception of the five moon illustrations in the *Sidereus Nuncius*, plus a few images of sunspots on the solar disk from his important 1612 work on the subject, even Galileo never again employed pictures (in that specific sense), either in his published works or in his notebooks. Moreover, for Galileo these pictures of the moon and sun served only to make points that were developed in the text; in other words, they did not stand by themselves in any meaningful way. Not that astronomers did not resort to visual tools or visual reasoning, of course: on the contrary, astronomical books continued to carry plenty of images, as they had always done. Those images, though, were not naturalistic depictions, but kept with the age-old tradition of astronomical diagrams, i.e., schematic representations of geometric configurations, spatial relations or motions, and not the visual *appearance* of celestial objects.

We are to believe that Hevelius profoundly changed the way in which astronomical practice and communication came to rely on images, inaugurating a new visual language. *Selenographia* is a treatise on the moon and its motions as much as a treatise on how to observe and represent its face. It may be read—or gazed at—as a visual narrative that strives to create several kinds of reality effects. Like any other astronomical book of the time, it has scores of diagrams sketching the relative positions of objects and the observer, angles of illumination, the behavior of light rays, and spatial relations in general. But there is something else as well: as Winkler and van Helden argue, Hevelius carefully sets a credible scene, which has himself working at the observatory. His observational procedures and equipment are thoroughly described in words as well as depicted through images. Besides writing at length about the details of his practice, discussing the best ways to manufacture a telescope, debating other astronomers' choices, he uses a novel (in astronomical books, at least) kind of picture as a powerful conveyor of meaning. These pictures painstakingly represent details of lens-grinding machinery, telescope parts, dark rooms, and so forth, and they stand on an equal footing with the text. A kind of climax is reached in a picture representing Hevelius himself in the very act of observing the skies through a telescope.

All this textual and visual technology has the effect of recruiting the reader as a witness, a "virtual witness," to Hevelius's work, which thus merits trust because it hides nothing. It is as if Hevelius were saying, "Look at me looking at the skies," immediately to add, "And look at what I have seen." Having taken the reader with him into the observatory, having described and depicted what happens there, Hevelius can now show what he discovered through the telescope. Trust in Hevelius's representations increases as the reader is reminded that Hevelius was not just the telescopic observer, but also draftsman and engraver, as I have already mentioned. With so many semiotic indices pointing to Hevelius's trustworthiness, as well as the text's scathing criticism of previous attempts to represent the moon, the reader is apparently ready to look at any of the multiple lunar images in *Selenographia*, let her eyes wander across the surface, so impossibly near, clear, and palpable, and believe Hevelius has rendered the moon "as it is."

As it is? Christian Jacob eloquently argues that this is not the case: "The selenographer draws not the image as seen through the telescope, but a mental image, a series of details that he must put as fast as possible in their places on the complete image," he writes. The gap between eye and hand is impossible to fill completely: "A drawing, painting, or engraving do not restitute whatever was not already inscribed in one's memory (…) Between observation and map lies a space of loss, displacement, and oblivion" (Jacob 2011, 623). Memory and indecision about what has just been seen thus appear as the key elements governing the very bodily work of the selenographer, in a manner rather unknown to the terrestrial cartographer working from previous models, templates, descriptions, coordinates. And Hevelius is the first to admit how much he has to rely on memory, writing that

> [a]t the very point of time when we sketch the figure and start a picture, we find out quickly that most, if not all, escapes our memory. It is therefore necessary that every little point is observed ten times or more before the proper place of some spot, its figure and its form, can truly correctly and accurately be reproduced on the paper.
>
> HEVELIUS 1647, 209

In order to produce a single portrait of the moon on a given phase, Hevelius has to move his whole body, stand up and sit down, repeat the same gestures dozens of times. But then the weather changes, clouds obscure his view, the moon moves out of sight, and a night's worth of observations and drawings is rendered useless. Indeed, the observational work that resulted in the apparently smooth sequence of 40 images of the progression of the phase cycle extended over more than two years. We can safely guess that each engraving must have started from a sketch that was corrected and retouched hundreds, maybe thousands of times.

If Hevelius's moon images really perform the naturalistic illusion of immediacy, this is acknowledged as the fruit of intensive labor. Of course, there is nothing new in this, since no one ever claimed that being "true-to-nature" was an effortless achievement. On the contrary, the whole idea of art in Hevelius's time revolves precisely around the specific effort that must be made in order to fill that "space of loss" that extends between the representation and the represented thing. Ultimately, belief in the representation has always been a matter of convention and voluntary submission on part of the viewer. What I want to contend, however, is that upon looking closely at Hevelius's lunar images we may become less certain about Winkler and van Helden's otherwise cogent argument about Hevelius's naturalism. This point has already been eloquently made by Kathrin Müller, who writes that "[t]his argument, however, oversimplifies matters and does not pay due attention to the variety of both the images in the book and the ways in which Hevelius employs them" (Müller 2010, 356). Echoing concerns previously voiced by Claus Zittel (2002, 14), Müller cautions against a blanket embrace of Winkler and Van Helden's argument, explicitly rejecting a view such as Adrian Johns's, who had written that "in Hevelius's books, the page was to be accounted a direct representation of the heavens" (Johns 1998, 437). Instead, Müller argues that "in many cases, Hevelius either verbally or by means of formal features openly draws the reader's attention to

FIGURE 8 Two successive views of the crescent moon included by Hevelius in his *Selenographia* (the left one between pages 416 and 417; the right one between pages 430 and 431). The inscriptions give information on the precise hour and dates of the observations (which were in fact not successive) and the celestial coordinates of the moon. However, they should not be taken to represent truly "instantaneous" views, for Hevelius had to go back to the telescope many times before he was able to finish each one of the 40 images like these in the book. Near the right-hand limb it is clearly possible to notice a slight change in the positioning of the surface features, resulting from the moon's libratory motion during the intervening months.
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the fact that [the reader] is looking at images (re-)designed for a printed book" (Müller 2010, 357).

Take the portraits of the moon in different phases. *Selenographia* includes no less than 40 illustrations of this kind, interspersed among almost 200 pages of text. Each picture differs from the previous one through the addition of a tiny new slip of illuminated surface or the subtraction of what has fallen into obscurity, as the moon wanes and waxes every month. The accompanying text offers a lengthy description of the new formations revealed, the changes in aspect of those that were already visible due to varying angles of illumination, and the conditions surrounding the observation. The whole sequence unfolds in time as a story in words and images, with an unequivocal narrative quality. But then, if we inspect any one of these phase portraits (Figure 8), there is something uncanny about them. As happened in Galileo's case, these portraits are at once seemingly familiar, indeed they look like naturalistic representations of *something*, and yet strangely unfamiliar, when, after looking around, one fails to recognize anything that really looks like them. It is impossible to achieve a sense of scale, for the images stand alone, without any standard of comparison. Granted, each phase portrait is invaded by textual signs that point to the external referent. All of them have a title such as, for instance, "This is the moon as observed from Gdansk on this specific date, its celestial coordinates being such and such." But raise your eyes to the moon on the same phase, and it simply does not look that way, even if magnified through a telescope. Indeed, telescopes and observational practices vary widely in the seventeenth century, and, just as with any other scientific instrument, one has to learn how to "see" any desired effect (Van Helden 1994).

But even for observers sharing the same observational standards, the gap between Hevelius's pictures and any instantaneous image will remain irredeemably open. The images are in fact composites of observations performed across different days, one phase almost invading the other, so to speak, in order for Hevelius to resolve features that were possibly hard to observe, retouch, or ascertain shapes and sizes of whatever he chose to draw. To this we should add that the orientation of the lunar disk in relation to a viewer's local horizon is continuously changing, besides being dependent on the observer's location on earth. Indeed, if one looks at the moon when it is rising, say, and mentally draws a "horizontal" line across the disk, a few hours later the same line will be "inclined;" and if the moon is observed at the same time from two different latitudes, one view will have to be rotated in order to perfectly coincide with the other. This is why the waxing moon looks like a 'D' on the northern hemisphere, and a 'C' on the southern. The result is that Hevelius's portraits of lunar phases can only "correspond" to the optical sensory experience of gazing at the moon, even with the aid of a telescope, if they are manipulated, rotated, and forced to fit the visual appearance. For naked-eye and telescopic observers alike, the endless details are nothing short of a new reality, a new visibility that is being imposed on the moon. The images are "both something less and something more than real space" (Jacob 2006, 14)—not unlike maps, even if they arguably do not cross the cartographic threshold.

So we are dealing at once with the persistence of memory (the act of passing from telescope to paper), the creation of a narrative (the sequence of represented phases), and a compositional act (adding up series of observations to produce a single image). Besides that, we have to keep in mind that Hevelius tries to portray something that is never "there," as his referent is permanently moving and changing. All of this indicates the centrality of *time* in Hevelius's endeavor: the time that is always threatening memory, the time along which the visual narrative unfolds, the scattering over time of the many partial views that add up to one composed picture, the impermanence of the moon itself.

The central question in Hevelius's work seems to be, more than naturalistic representation, nothing less than putting time under control: he strives to find ways to depict realities that are ever mutating, to impose a synchronic order to asynchronous processes.

Nowhere more than in the full-moon maps that come with *Selenographia* is this quest more apparent, and in important ways they are maps precisely because of the way Hevelius finds to represent time in them.

4.2 *Hevelius's Cartographic Invention*

Already the first representation of the full moon in *Selenographia* (Figure 9) strikes the viewer as some kind of cartographic image. Where does this identification come from? There are certainly some family resemblances that hint to such identification. It is not a representation of "something" that takes place somewhere else, but a "world" that is in itself a totality, a world that contains all its own spatial relationships without the need of a physical outside. A circular graduated scale along the outer edge of the moon marks the boundary of this world and imposes on it a geometrical order, adding to the recognition of the image as full-fledged map space, not an attempt at naturalistic depiction of an object.

What is more striking is that we can see not only one edge or limb marking the boundary between the blank page and the inner map space, but two. We are before two slightly offset, but still clearly visible, circular disks representing one and the same face of the moon. Our eyes may get a little confused, for around the center of the image we do not see a hint of its being composed by two overlapping, offset disks. But as we get close to the edges, the double line asks to be deciphered. The two graduated circular lines cross approximately "east" and "west" of the image, but it is not easy to follow one rim without inadvertently crossing over to the other. And what are the crescent-shaped spaces between both arcs, "north" and "south" of the image? The crescents seem to be seamlessly connected to the central region, common to both disks, but it is hard to be sure, since the very presence of the graduated circle makes it difficult to ascertain whether the delicate engraved lines are continuous or not. Adding to the visual puzzle, this is unlike what one is used to find in double-hemisphere terrestrial maps, where the disks do not overlap and simply represent two different "faces" of a spherical object.

What Hevelius is trying to convey with the two offset overlapping disks is the fact that through time one sees not just half of the moon, but almost 60% of its surface. In other words, all that can be seen of the moon *over time* does not "fit" in any straightforward manner on a circular disk. It is a situation analogous to what would occur if one tried to (orthographically) represent a

FIGURE 9 The first image of the full moon in *Selenographia* (between pages 220 and 221), already showing the double rim, i.e., Hevelius's solution to the problem of how to represent the changing face of the moon resulting from libration. Topographical features are subdued in order that variations in total brilliance (albedo) may be highlighted.
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globe from two different angles at once: there is more information than may be squeezed onto a flat disk. At any given instant, half of the surface area of the lunar body is observable—to be thorough, not exactly half of the moon's surface is visible to us at any single instant, because the moon is not at an infinite distance from the earth; but this is negligible. As weeks and months pass by, though, some observable features gradually fall out of sight, as they seem to approach the edge of the disk and then vanish, whereas others become visible at the diametrically opposite region. The two superimposed disks are the way Hevelius found to represent the extreme possible views: one shows the maximum "southeast" portion of the moon that can possibly be viewed, with the "northwest" crescent region out of sight, and the other disk shows the opposite extreme. Most of the time, an observer will not see either one of the disks, but some intermediary situation. The lunar features located on the crescent-shaped wedges vary in their visibility.

The phenomenon that Hevelius sought to represent by superimposing the two disks is what is known as the optical libration of the moon.[22] It results from a combination of properties of the moon's orbital motion around the earth. In order to understand it in very simplified terms, we must first notice that the moon's own axis of rotation is not perpendicular to its orbital plane but inclined along a fixed direction in space. As a consequence, an observer on the earth's surface will at times be able to see the region around the moon's north pole, with the south pole falling out of view, and at other times she will see the opposite. This results in an apparent "wobbling" oscillation of the "north-south coordinates" of visible features. Another wobble, this time in longitude, is related to the fact that the moon's orbit is not circular, but elliptical, which causes an observer to see more of the western or eastern regions of the lunar surface at different times. (There is also a small amount of wobbling that results from the fact that no one observes the moon from the earth's center, but from its surface, causing a parallax shift.) The different kinds of libration add up in a complicated way, with the consequence that any given instantaneous visual appearance of the moon will not be repeated when it reaches the same phase on the next month, as one might intuitively expect, but only after a few years. In other words, the disk that is visible on, say, this month's first day of the full moon is slightly different from next month's, which is different from the next, and so forth. The difference lies on the surface features that can or cannot be observed close to the limb, as well as the placement of the geometric center of the lunar disk as it appears to one's vision: the center is not fixed on any given observable feature, such as a crater or valley.

There is much discussion as to whether Galileo had already identified the existence and causes of the moon's librations over time, but undoubtedly it was Hevelius who brought the matter to the fore, making it a central concern of

22 See Włodarczyk (2011) for a detailed explanation of this phenomenon.

Selenographia[23] (Włodarczyk 2011). He took great pains to produce an empirically satisfactory account of the phenomenon, and then to express it visually: the superimposed offset disks represent the visual solution he devised to the problem of representing something that changes in appearance over time. It is of paramount importance that we understand that the image does not correspond to anything that one would be able to *see* at any moment, even with the aid of a telescope. Rather, it condenses, or *concretizes*, in one representational space, the maximal visual manifestations of a temporal phenomenon. By representing something that cannot be seen by any observer, who is of necessity bound to a determined moment in time (and to a place in space), Hevelius is in fact doing away with temporal unity, one of the important concerns of pictorial mimesis, while staking all on the acceptance of a new convention. The very first full moon image in *Selenographia* is more than a picture; it is a spatialization of a time-dependent set of underlying positional relationships between features of the moon's surface.

Arguably, the image is a map in a rather "strong" sense: it is by necessity not intended as pictorial mimesis (although it certainly explores some of the conventions of mimetic representation), and it subsists solely in a conventional representational space that bears an arbitrary relation to the represented entity and its internal spatiality. But the image still lacks the dense semiotic apparatus that gave Van Langren's map its cartographic identity. This is to be found in the three foldout full moon maps.

The first one (Figure 10) is a faithful reproduction of the previous image, in larger size. Like that one, it shows the two superimposed disks with the graduated rim. This time, however, the surrounding space is not blank, but is occupied by ornaments placed at the four corners. On each corner a pair of *putti* perform a specific function. On the upper left of Figure 10, the *putti* hold a banner with the title of the map ("The natural face of the full moon"), a statement of authorship and date ("drawn and engraved by Johannes Hevelius in the year 1645"), and details of what is shown ("with the edges of the disks of maximum and minimum libration in both directions"). Hevelius is careful to claim the moon and its librations had "never before been so accurately observed." Then, at the upper right corner of Figure 10, the *putti* stretch a banner containing a passage from Seneca's *Natural Questions*, according to which nature only reveals its secrets to those who patiently and laboriously go after them. At the lower left of the same image, one *putto* kneels on the floor holding

23 Van Langren explicitly mentions libration in the inscription on his map, and announces he has a complete description of the phenomenon, which he claimed would be demonstrated with the aid of a lunar globe he was supposedly making.

FIGURE 10 The same image as before, but now enlarged (foldout between pages 222 and 223) and framed by *putti* and scale keys.
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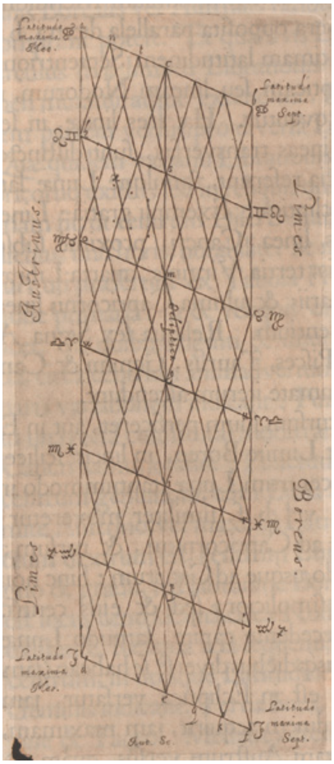
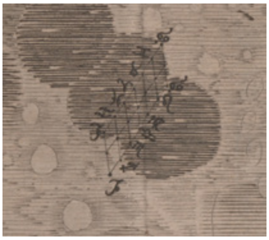
a large book open, while the other sits on a stool and draws on the book with a compass; below them there is a scale showing real distances in German miles. Finally, the *putti* at the lower right corner are shown making measurements: one of them observes the moon with a telescope that he holds with one hand, a graduated staff in the other, and the second one draws in a sketchbook. Both capture aspects of Hevelius's own work. Below them one can see another scale, this time angular, in degrees of the ecliptic. It can almost go without saying that the corner scenes, with banners, inscriptions, scales, and instruments of the trade are indices of the sheet's belonging to what any reader would identify as the class of objects called maps.

Now, let us remember that another effect of libration is that the geometric center of the visible face of the moon will keep changing its location in relation to surface features themselves. The path described by the visual center is not a simple figure, such as the line-segment joining the two centers of the



11a



11b

FIGURE 11
Hevelius came up with a provisional graphical device to locate the center of the effectively visible lunar disk at any moment of the libration cycle, seen here on Figure 11a. The device was placed on the central region of the map, as shown on the detail (Figure 11b).
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disks representing the states of maximum libration. Hevelius was able to come up with an ingenious, albeit provisional, graphical device that allowed observers to approximately pinpoint, on the image, the location of the center at intermediary states of libration—it was provisional because, to Hevelius's own admission, the device would stop furnishing the roughly correct position of the center within observational limits after a few years. He succeeded in this because he found a way to express the state of libration as a function both of the moon's position along its orbit and the earth's position around the sun. The graphical device was a diamond-shaped graticule that Hevelius described in general terms, with great care (Figure 11a), and also placed on the central region of the double-disk image (Figure 11b). In possession of the values of the aforementioned moon-earth and earth-sun orbital parameters, the reader only had to locate them along the oblique axes of the graticule and plot the point that corresponded to the coordinate pair. This point was the approximate geometric center of the visible disk for the specific moment in time that was encapsulated in the orbital configuration itself. From this center the observable position of the limb at that precise same moment could be traced with a compass (Włodarczyk 2011).

Notice then how Hevelius was offering his readers what looks like a map-instrument, even more than a map-image. Of course it could not be *used* to go anywhere, to place anything, but it could still solve, graphically, a specific kind of problem. Hevelius created a cartographical object that could not only be rotated to "match" visible reality (however carefully we have to interpret this operation), but he was doing something much more profound: cartographic space itself, not only the material object, was in a way open-ended. He gave two possible appearances of the lunar surface, but readers might find using their own means what the disk would "look like" on any other occasion. Hevelius furnished a cartographic base-space whose limits change over time, and it was up to readers to find the boundaries of this space at a given moment.

The two superimposed libration disks that make up the cartographic base-space in this map and the previous one represent the full moon under direct solar illumination, i.e., the "real" condition of visibility. The effect of direct illumination, as we have seen before, is to make topography difficult to discern, with edges losing sharpness and small-size features getting fainter or totally disappearing. The next map addresses these problems directly, in a very radical way (Figure 12). Again we are in front of the two libration disks and ornamented corners. The banner carried by the upper-left corner *putti* in Figure 12 gives the map's title as *Tabula Selenographica*, adding that it is "a true orthographic delineation, made with the aid of the telescope, of the seas, bays, islands, continents, promontories, lakes, wetlands, mountains, plains, and valleys that exist on the visible surface of the moon." Hevelius willingly surrenders to terrestrial cartographic conventions. All of a sudden, the lunar surface is filled with earth-like "geographical accidents," marked on the image with proper names coming straight out of ancient geography: *Mare Mediterraneum, Insula Corsica, Pontus Euxinus* … The textual surroundings of this outline map reinforce the transformation of the moon in a kind of earth, as effected in and by the map. In the text pages among which the map was to be inserted, Hevelius discusses at length how he came to his nomenclature, noting that the definitive step was taken when he had the revelation that the moon's surface was the exact mirror of the earth's. The resort to ancient and biblical geography to baptize the features of the moon's surface, in which he believed he saw the Ptolemaic ecumene, was an irenic gesture. He borrowed toponyms from Abraham Ortelius's *Thesaurus* and the Bible, consciously avoiding Van Langren's overtly political decisions. The result, writes Nydia Pineda, "was not just an accommodation of terrestrial cartography onto a survey drawn from the telescope, but was in itself a representation of cultural transfer: the geography of most interest to humanist and

FIGURE 12 In the second foldout map included in *Selenographia* (between pages 226 and 227), Hevelius sacrificed albedo to topography and nomenclature.
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biblical scholarship was projected onto the moon. The reader would revisit mythology, history, and texts conveyed through the nomenclature" (Pineda de Ávila 2017, 176–177).

Van Langren had organized his map space according to a metageography based on stark, simple oppositions: lands and seas, large and small, central and peripheral. The symbolic order imposed by Van Langren's choice of nomenclature was accordingly organized in the same dualistic way: large and/or central areas are named after powerful patrons, which in turn determine the names that should or should not be given to nearby features. Hevelius offers instead a more nuanced hierarchy of forms, sizes, and relationships. The banner on the upper-right brings a legend with the key to the legibility of the map: *M* is for mountains, *I* for islands, *Pr* for promontories and so on. Not only is the map now covered with toponyms, the visual representation itself has undergone a profound transformation: what on the previous map was simply shaded now gains a rich texture, and small hills or mounds abound along the

FIGURE 13 Detail of the map in Figure 12, showing Hevelius's use of rows of "mounds" and broken, wavy lines to create topographical texture. COURTESY ETH-BIBLIOTHEK ZÜRICH (RAR 8932 Q, DOI 10.3931/E-RARA-238)

boundaries between dark and light regions. What is more, Hevelius inverts the overall shading scheme, in such a way that "bodies of water" are no longer dark, but vast blank spaces populated by occasional "islands," as viewers were used to find in terrestrial maps (Figure 13). The *putti* at the lower corners seem not to be contemplating from a distance any longer, but actively engaging in survey work. One of them holds a telescope that is not pointing upwards, to the sky, but straight ahead, to the "field." The distance scale becomes a ruler that can be grabbed and applied to the terrain. The moon is barely a celestial object anymore, but a world as near and palpable as the earth; the moon map looks almost undistinguishable from a terrestrial one.[24]

4.3 *Eclipse Maps and Do-It-Yourself Cartography*

Time is central to another kind of map present in *Selenographia*, those representing lunar eclipses. Eclipse maps would have a vast progeny over the next centuries, and they remain popular among sky watchers. A lunar eclipse map

24 The third foldout full moon map is similar to the one shown in our Figure 10, but highlighting the surface relief, with an oblique source of illumination (of necessity artificial, for the real full moon occurs under conditions of direct incidence of sunlight).

basically represents a number of different positions occupied by the earth's shadow on the moon's surface during the course of an eclipse. The position of the arc that marks the edge of the shadow is shown at set intervals, as in Figure 14.

The most obvious use of such maps has to do with the determination of the longitudinal difference between two observers that are able to exchange their records of a lunar eclipse. The idea behind the method is deceptively simple: both observers just have to measure the local time (i.e., the "true" astronomical time at each observer's location) when the earth's shadow reaches a given feature on the moon's surface. If they really observed the same moment of the eclipse, as determined by the progression of the shadow, the difference in their records of local time translates into the relative longitude between their earthly stations. Since lunar eclipses are fairly frequent, and, unlike solar ones, are visible by all observers for whom the moon is above the horizon, the method should provide an easy means of determining relative longitudes: all that was needed was to plot the evolution of the shadow, taking care to mark the local time when it attained such or such a position on the lunar disk, and compare it to similar plots received from elsewhere.

Hevelius provides his readers with the necessary "instrument" for recording and exchanging the time development of a lunar eclipse, in the form of highly simplified cartographic bases or templates that the reader might copy in order to plot her own eclipse observations and exchange them with other practitioners (Figure 15). Such exchanges indeed occurred, as is witnessed, for instance, by the fact that Hevelius's eclipse template was included in some issues of the *Philosophical Transactions* of the Royal Society, and the society's archive keeps a few precious examples that were sent back, overlaid with shadow-boundary arcs delicately drawn by their senders (Pineda de Ávila 2017, 232–243).

Although it was in principle capable of delivering the much sought after longitudinal differences, the eclipse method was plagued by impracticalities that rendered it quite unreliable. In the mid-seventeenth century, the most important obstacle to a successful employment of the method was located in the observation process itself: a number of optical processes conspire to make the shadow boundary on the moon's surface considerably diffuse, even if viewed through the telescopes then available. As a consequence, it was all but impossible to reach any degree of consensus on what it meant for the shadow to reach a given surface formation (or, which amounts to the same thing, to find agreement on where exactly one should "see" the boundary between light and darkness). Besides that, the measurement of local time was very difficult to achieve to a level of accuracy that would not translate into egregiously large errors on the relative longitude estimate.

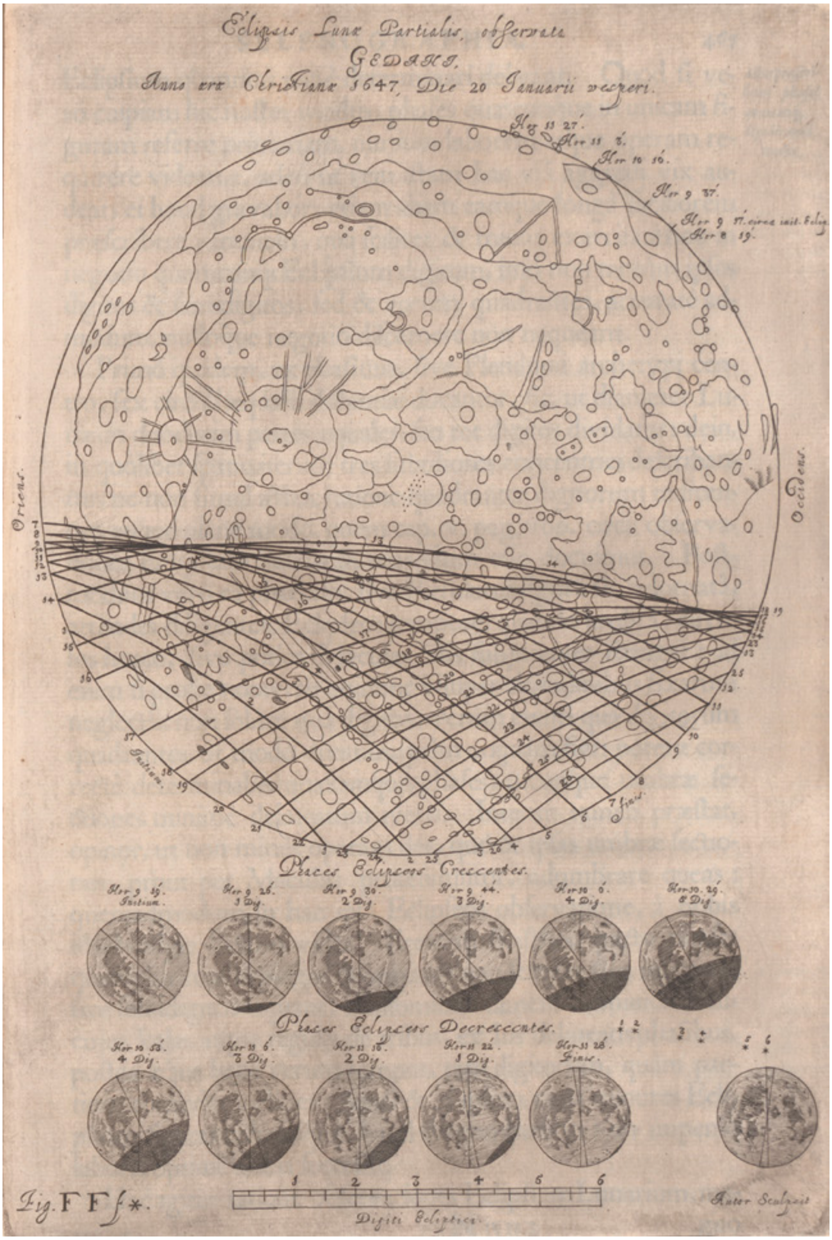

FIGURE 14 A complex image representing the time-evolution of a lunar eclipse (inserted between pages 466 and 467 of *Selenographia*). The larger image shows a highly schematic outline of the moon's surface, without topographic or albedo markings, in order to value the geometry of the earth's shadow boundary successive positions.
COURTESY ETH-BIBLIOTHEK ZÜRICH
(RAR 8932 Q, DOI 10.3931/E-RARA-238)

FIGURE 15 Hevelius's template or "base" map ("Figura Pleniluniorum Generalis," between pages 548 and 549), which was to be used by eclipse observers irrespective of the libration state. Highly simplified, the image does not even show the moon's edge, which readers should plot themselves on the occasion of a specific eclipse, along with the arcs marking successive positions of the earth's shadow.
COURTESY ETH-BIBLIOTHEK ZÜRICH (RAR 8932 Q, DOI 10.3931/E-RARA-238)

By the late seventeenth century, though, there was hope that improvements in instrumentation could mitigate those problems. Thus, eclipse maps registering the local time for a number of successive positions of the shadow boundary might, after all, meet with their intended use. But there was another important question that had to be faced before that: there was no point in comparing two eclipse maps if they did not record the same events. In other words, the observers would have to agree beforehand on exactly what surface features would have the instant of their shadowing recorded. This could be solved if a central authority determined which surface features should command observers' attention, and then collected and compared the records made by astronomers positioned on different locations.

Giovanni Domenico Cassini was the individual with the necessary resources, including personal and institutional power, to promote this kind of centralization, that is, to establish a standardization of observational protocols, or at least to gather a large enough number of not necessarily uniform records (and then see if it was still possible to compare them in some way). The dominant figure of French astronomy since the 1670s, when he founded the Paris Royal Observatory on Colbert's invitation, an intimate of Louis XIV, and an influential member of the Académie des Sciences, Cassini spent decades overseeing large astronomical and cartographic projects that could only come into being through the mobilization of large networks of practitioners.

In the *Mémoires* of the Academy meeting of August 30, 1692, we find Cassini reporting at length on the lunar eclipse that had taken place on July 28. After learning that bad weather in Paris prevented the Royal Observatory from recording the eclipse from start to end as minutely as Cassini had hoped for, we read that "in several other towns where M. Cassini maintains correspondence with talented astronomers, who were thoroughly prepared to observe the eclipse, the weather has not been more favorable." Some of these astronomers were under Cassini's direct orders, as we are told: "M. Beauchamps, gentleman of Avignon, has been expressly dispatched to Carpentras to observe the eclipse therefrom (...); in Aix, M. Brochier was prepared to make the observation; and M. Cassini's eldest son was placed in S. Malo" (Cassini 1730, 151–152). Four other astronomers are also mentioned, but it is not clear except in one case whether they had been "expressly dispatched" by Cassini or had voluntarily sent in their results to the Royal Observatory.

Even if all observations were hampered by bad weather, preventing the observation of the same events along the shadow's progression, Cassini was able to devise a method that could still extract something from the data. He showed that with records from at least three different observers, it was possible in principle to work out mathematically the longitudinal differences even if they had not registered exactly the same events. The demonstration was textual and graphical, and for the latter Cassini employed a typically Hevelian template map.

Cassini was also involved in the establishment of a heavily reproduced, used, and circulated map that first appeared in the same context of eclipse observations. Much less schematic than the Hevelian templates, it was probably based on an earlier, somewhat ill-fated attempt to produce a highly detailed, very large engraving that Cassini had undertaken in the 1670s, which we have already encountered in Figure 5b.[25] A version of this map first appeared in the almanac of the Paris Observatory, *La Connoissance des Temps*, in 1702, and over the next few decades returned in slightly different versions. In 1730 it came out in its most iconic, frequently reproduced form (Figure 16), when the Académie the Sciences decided to print the *mémoires* of its seventeenth-century meetings. There is a dense textual layer, with letters referring to notable features that Cassini had selected as especially important for eclipse observers. The title is interesting in itself, for it suggests that the image represents the "mean libration." In reality, it is not in any sense an "average" over all possible views of the moon's face as it changes due to libration, as one may inadvertently suppose, but an estimated, and once again, "eyeballed" depiction.

4.4 *They Have Been Hevelian Too*

Giovanni Battista Riccioli (1598–1671) is one of the most famous Jesuit astronomers of the mid-seventeenth century. In his own time, however, fellow Jesuits had doubts regarding his technical skills (Pineda de Ávila 2017, 48–49). His immense *Almagestum Novum* of 1651 was an attempt to revisit the whole history of astronomy and settle, once and for all, the problem of the true "system of the world," which he took to be Tycho Brahe's geo-heliocentric model, and in no way Copernicus's heliocentric one (Graney 2015). Above all, the book was also Riccioli's claim to credibility among his peers, an overwhelming act of self-fashioning. Since he set about touching upon every astronomical subject that had ever been developed by others, it is no wonder that he devoted a few of the book's more than 1,500 densely packed, two-column pages to selenography. Besides, maps of the moon were already regarded as objects of prestige, capable of causing a lasting, positive impression on readers and patrons alike (Pineda de Ávila 2017, chapter 1), so it is no wonder that *Almagestum Novum* contained two such charts, drawn for Riccioli by fellow Jesuit Francesco Maria Grimaldi. What strikes me the most about the first one (Figure 17) is how thoroughly Hevelian it is: it employed exactly the same solution to the problem of how to represent the moon's changing appearance through overlapping, offset circles corresponding to libration maxima. The second (Figure 18) could be more properly called a "view," if we are to follow Christian Jacob's aforementioned suggestion; it could obviously be paired up with the series of moon images with a naturalistic aspiration that I have previously proposed.

Virtually all the specialized literature on Riccioli and Grimaldi's maps of the moon is devoted, however, to highlighting how different they are from

25 For a careful analysis of this project and the resulting image, see Pineda de Ávila (2017, 108–110 and 121–123, and references therein).

FIGURE 16 Cassini's large moon engraving prepared by Jean Patigny (Figure 5b) reached a very restricted audience. Another, very simplified version of the image, had enormous success during the eighteenth century, and was reproduced innumerable times in almanacs, textbooks, encyclopedias, and periodicals. Shown here is a version included by Pierre-Charles Le Monnier in his *Institutions Astronomiques* of 1746, itself a version of a famous astronomical textbook by John Keill, published in Latin in 1718 (with many subsequent editions). Le Monnier's map is, in turn, a faithful reproduction of the one that had already appeared in 1730 in the first printing of Cassini's 1692 communications on lunar eclipses to the Académie des Sciences.
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FIGURE 17 Riccioli and Grimaldi's moon map (included between pages 204 and 204 ½ of the first volume of the *Almagestum Novum*) adheres to Hevelius's solution to the problem of how to represent libration, with the pair of offset circles, although Riccioli proposes another graphical device to locate the visual center of the lunar disk (the small circle at the center). The map does away with Hevelius's naming scheme, however, putting in place a system based on rules about what names could appear in each one of the octants clearly discernible in the image. A balance between topography and brilliance is attempted by a clever use of the varying spacing and angles of the line incisions. COURTESY ETH-BIBLIOTHEK ZÜRICH (RAR 9471, DOI 10.3931/E-RARA-520)

Hevelius's (see, e.g., Whitaker 1999, 60–68; Montgomery 1999, chapter 12; Vertesi 2007; Pineda de Ávila 2017, 177–183). In very important and consequential ways they really are. Great importance is accorded to the fact that Riccioli devised yet another nomenclature scheme, which he explains in full detail in the text. His system of choosing names for the features on the lunar surface was poised to supersede Hevelius's, and, to some measure, is still in use.

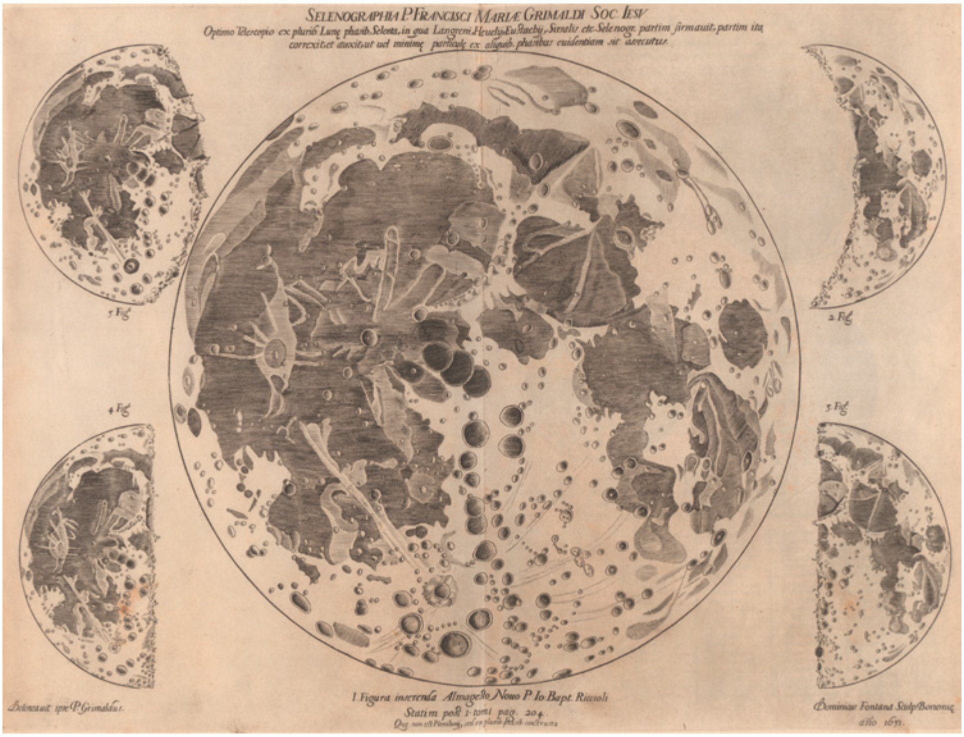

FIGURE 18 Immediately following the previous map, this second image clearly puts greater weight on volumes and suggestions of tri-dimensionality. It is not topographic, though, but much more in line with the naturalistic tradition. Also absent is the double outer edge.
COURTESY ETH-BIBLIOTHEK ZÜRICH (RAR 9471, DOI 10.3931/E-RARA-520)

Riccioli's name choices and their distribution over the moon are overtly political, unlike Hevelius's irenic proposal. But their politics is also not the same as Van Langren's: it is the politics of the Republic of Letters itself that is allowed to be represented on the map. Innumerable astronomers and philosophers from Antiquity onwards receive their share of lunar territory, accorded to each one on the basis of merit, but also of religious allegiances. Unsurprisingly, Roman Catholics get the "best" spots, i.e., larger, more central ones or those nearer to pleasant regions such as the Sea of Tranquility, not the Ocean of Storms.[26]

26 It is interesting to note that the Latin inscription below the map's title translates as "Neither do men inhabit the moon, neither do souls migrate there." Riccioli is thus clearly rejecting any credence of earth-moon parallelisms based on assumptions of a real mirroring, and openly embracing the artificial, arbitrary character of the politics he projects on the lunar surface.