Finding a method to determine terrestrial longitude was critical in the early seventeenth century as countries attempted to establish territorial boundaries. The magistrate and natural philosopher Nicolas-Claude Fabri de Peiresc (1580-1637) spent much of his life working on a solution to this problem. As an early technical communicator, he was concerned with the criteria of acceptable observations, the standardization of materials and methods, and the communication of results. He refined a variety of strategies to obtain these observations and ensure their accuracy. He persuaded missionary priests to make observations throughout the Levant by promising patronage and gifts or stressing practical applications in the solution to the problem of longitude and church calendar reform. Although Peiresc did not resolve the issue of determining longitude, his efforts did provide the basis for work by later astronomers.

Seventeenth-Century Technical and Persuasive Communication

A Case Study of Nicolas-Claude Fabri de Peiresc's Work on a Method of Determining Terrestrial Longitude

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Efforts to determine longitude in the early seventeenth century were plagued with problems, including the lack of accurate timepieces and instruments. Many individuals such as Galileo vied for the prestigious prize of a lifetime pension for finding a method of determining longitude. As a significant player in the quest for longitude, the French natural philosopher and humanist Nicolas-Claude Fabri de Peiresc (1580-1637) devoted much of his energy and income to this quest.

Peiresc played an important role in organizing and communicating scientific observations in the early seventeenth century. Nobility, ties to powerful circles, and friendships with cardinals enabled him to carry out investigations of natural phenomena and communicate results at a time of censorship and the Inquisition. He served as an intermediary in correspondence networks stretching throughout

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Europe and the Mediterranean basin and shared news of scientific innovation. From his homes in Aix-en-Provence and Belgentier, he sent information through correspondence networks, which required one week to reach Paris, two weeks to Rome, and approximately six weeks to the Levant. As an early technical communicator, he was concerned with the criteria of acceptable observations, the standardization of materials and methods, and the communication of findings. Peiresc has been described as a man who resorted to "kindness, persuasion, ruse . . . threats, supplications . . . to achieve goals" (Aufrère and Foissy-Aufrère 182). The success of the longitude project was based on his persuasive skills.

This article examines the strategies Peiresc used to convince individuals to follow a procedure for telescopic observations and provide technical data for his work on determining a method of terrestrial longitude. More specifically, it analyzes his communication techniques: the methods he used to persuade individuals to make telescopic observations in a period of censorship and to standardize procedure and gain recognition for claims based on observation and inquiry when truth and certainty rested on the traditional authorities of Aristotle and the scriptures.

In a period of censorship and the Inquisition, published works reflected traditional views. Correspondence, however, revealed private exchanges giving shape to scientific debate. Correspondence provides insight into Peiresc's strategies to legitimize observations, use of persuasion to secure compliance, and persistent efforts to standardize materials and methods to improve the quality of telescopic observations. The Peiresc correspondence provides a case study of scientific activities. From the time Peiresc first procured a telescope in 1610 to his organization of observation stations starting in 1628, he systematically recorded astronomical data.

This article focuses on Peiresc's work in observational astronomy between 1610-12 and 1628-37, times when he worked on determining a method of terrestrial longitude. For my research, I have relied primarily on the published Peiresc correspondence (Tamizey de Larroque, *Lettres*, *Correspondants*; Apollinaire de Valence; Tannery, de Waard, and Beaulieu), which covers a period of 40 years. I have also consulted smaller editions of related correspondence, but for the most part, they focus on his interests in history, philology, archaeology, and numismatics. I also used secondary sources (Chapin; Humbert, "Problème"; Van Helden, "Longitude") to identify the main periods of Peiresc's work on longitude. Additionally, I consulted Alexandre

Pingré, who has identified participants observing celestial phenomena in the seventeenth century. Both Guillaume Bigourdan and Pierre Humbert have indicated the level of involvement and competence of many individuals assisting Peiresc.

At his death, Peiresc left more than 10,000 letters. Less than one-third of these letters have been published (Hatch 19, 32). The correspondence edited by Tamizey de Larroque is incomplete and unorganized. The editing and expurgation of passages deemed "too scientific" by Tamizey de Larroque have limited the conclusions that can be drawn, particularly concerning Peiresc's level of scientific competence (Humbert, *L'oeuvre* 7). Only comparisons between the original handwritten letters and the published versions indicates the extent of indiscriminate editing. However, although Peiresc made noteworthy astronomical observations, his main contribution, according to existing scholarship (Chapin; Hatch; Tolbert; Van Helden), seemed to be his ability to conceptualize and implement a project rather than his scientific expertise. Peiresc deferred to the more skilled astronomers, clerics Joseph Gaultier and Pierre Gassendi, for the collation and interpretation of data.

In contrast to the Tamizey de Larroque publications, the Mersenne correspondence (Tannery, de Waard, and Beaulieu) is annotated and indexed, providing a baseline for scientific activity of this period. Another volume of correspondence (Apollinaire de Valence) focuses on exchanges between Peiresc and missionary priests in the Levant and provides information about the organization of observation stations in the 1630s.

The majority of extant unpublished Peiresc correspondence is located at the Bibliothèque Inguimbertine in Carpentras, France. Copies of these original letters made by a member of the Peiresc household are located in the Bibliothèque Méjanes at Aix. Peiresc wrote mainly in French. His correspondence has not been translated into English; the translations in this article are my own.

The editing of the published volumes of Peiresc correspondence and biases inherent in primary sources (e.g., letters geared toward a specific audience, the difficulty in accessing tacit beliefs) affect my interpretation. But Peiresc's role as a persuasive and technical communicator can be understood through a thorough study of primary and secondary sources.

One challenge in this study has been linking the activities of the scientific subculture to the broader political, social, and cultural framework. Research in persuasive communication and patronage has provided this connection. *Persuasion* involves influencing behavior through implicit or explicit requests (e.g., for a telescopic observation) and providing incentive for compliance (Wheeless, Barraclough, and Stewart 114, 120). The related concept of patronage is useful in understanding the mechanism of persuasion and compliance. *Patronage* is a system of relationships between patrons and clients often arranged by an intermediary in which social status and legitimacy might be traded for services or information. An early study on gift giving and patronage in indigenous societies by the French anthropologist Marcel Mauss and the applications of these concepts to seventeenth-century France by the historian Sharon Kettering have been adopted for my analysis. Both persuasion and patronage are related to the concept of power, or potential. Power is associated with the ability to provide reward, expertise, and status. Peiresc promised gifts or patronage positions as incentives to fulfill his requests. Because his authority was grounded in the church and crown, he had the authority to legitimize scientific activities and the power to gain compliance.

The use of persuasive communication strategies was critical to the success in the work on determining a method of longitude. This article begins with an examination of the context of Peiresc's work, a time of geographical discovery and of questioning the traditional worldview. The first sections of this article provide a chronology of Peiresc's work in the organization of observation stations and the collection of data. They include a discussion of his use of persuasive strategies to ensure compliance for requests and to refine his materials and methods. The article concludes with an analysis of his role as a technical communicator.

BACKGROUND

The problem of determining longitude on land and at sea became increasingly important with exploration and trade. Geographers needed to indicate precise territorial boundaries. Already problems had occurred when in 1493, Pope Alexander VI issued the Bull of Demarcation, dividing the New World between Spain and Portugal. At this time, no physical location for the meridian and hence no method of determining this division of land between competing countries existed.

Whereas latitude was calculated by measures of the altitude of the noonday sun or the height of the polestar, longitude involved a difference in time between two locations. Because no accurate timepieces existed and astronomical tables contained errors, comparing time differences between a lunar eclipse viewed at one location with predictions provided by tables for that eclipse at another location was impossible. Furthermore, the prime meridian varied with the observer. That is, Peiresc might consider Aix his prime meridian, whereas his Parisian or Roman correspondents considered these cities as their prime meridian. Adjustments for the location of the meridian of each observer complicated the task of collating data.

The solution to the problem of determining longitude on land and at sea would be a moneymaking venture. In 1598, Philip III of Spain offered a lifetime pension for the discovery of a reliable method for determining longitude at sea. Navigators and cartographers could estimate locations from readings of the magnetic compass and astrolabe, or they could use dead reckoning—estimates based on the ship's log—to determine distances traveled east or west of a port. However, these estimates often did not suffice, and countless incidents of ships crashing into rocky coastlines or departing from their courses were attributed to errors in determining longitude. The ancient Greek Hipparchus had introduced the lunar eclipse method, but without instruments, astronomers could not provide precise measurements.

EARLY WORK ON A METHOD OF DETERMINING LONGITUDE

The advent of the telescope and Galileo's discoveries of the four moons of Jupiter, described in his *Sidereal Messenger* (1610) (Galilei *Sidereus*), dedicated to Cosimo II de Medici, seemed to offer a viable solution to the problem of longitude, as Peiresc explained to an unidentified correspondent in a letter dated September 20, 1611:

> When you are in the Azores, for example, and see a configuration of these stars, which could only occur at a certain hour in Aix, finding them at another hour, you would agree that you are on the meridian corresponding to the difference in hours. (qtd. in Humbert, "Problème" 383-84)

That is, an observer at point A might view a pattern of stars at 9 p.m.; an observer at point B might see this same pattern at midnight; the three-hour difference in time would be converted to the difference in longitude in degrees. Successful observations involved overcoming numerous barriers. For example, most telescopes were of low power and had a small field of view, and lenses often distorted light and image. No optical theory existed to explain the workings of the telescope. Observatories were rudimentary by today's standards and often consisted of a telescope in an open field, on a rooftop, or in a room with a large window. Furthermore, existing astronomical tables were based on naked-eye observations, some of which had been made centuries earlier.

To test the determination of longitude using the Jovian moons, astronomers needed first to construct tables of planetary movement, with an accurate time of orbits, to account for the movement of Jupiter around the sun. Peiresc began observing with the priest Joseph Gaultier in November 1610, and he invited colleagues, trained in observational procedure, and friends to participate. He also acquired data from Galileo, under whom he had studied while in Italy (1599-1602), and Kepler, which he hoped to supplement with observations from astronomers in the Orient and the New World.

In 1612, he equipped his colleague Jean Lombard with telescopes and instructions to make observations during a four-month trip in the Levant. Peiresc planned to dedicate astronomical tables based on these observations to the queen regent of France, Marie de Medici, to continue Galileo's metaphor of Medicean stars. But he never completed the project, perhaps because of inaccuracies in measurements or because Galileo had undertaken a similar venture. Still, the effort was significant because Peiresc used firsthand observations made with instruments (Gassendi 116-17).

Peiresc and many members of the clergy focused on the practical applications of Galileo's observations. But the implications of these discoveries by the Italian soon caught the attention of the Roman Catholic Church. The church accepted the concept of the Ptolemaic system, in which all planets revolved about the earth, and celestial bodies were perfect and immutable. However, telescopic observations of the Jovian moons, the pitted lunar surface, and the distant stars of the Milky Way described in the *Sidereal Messenger* and later observations of the phases of Venus and the sunspots provided evidence refuting the accepted notion of a geocentric and finite world. In defiance of Galileo's discoveries, the Roman Catholic Church issued the Injunction of 1616, prohibiting the teaching and support of the Copernican worldview, according to which all planets revolved around the sun. However, the church continued to support observational astronomy, which could provide a method of dating religious holidays such as Easter, which occurs on the first Sunday after the full moon following the vernal equinox. By stressing the practical use of observations such as in calendar reform, Peiresc attempted to justify the importance of telescopic astronomy.

Even though Peiresc initiated an intensive program in longitude and had financed a telescopic expedition, he appeared to have abandoned the longitude project while in Paris (1616-23), when he served as secretary to a political figure in the royal entourage. He returned to these astronomical investigations in 1628, then using observations of the lunar eclipse. His published correspondence makes no mention of the organization of observations for the lunar eclipse of January 20, 1628, but subsequent letters indicate Peiresc's role in the organization of observation stations and the collection of data. Furthermore, as an intermediary in correspondence networks, he played a fundamental role in the communication of results to the scientific community. At a time of censorship, most scientific communication took place in the private academies linked by correspondence networks.

ORGANIZATION OF OBSERVATION STATIONS

Throughout his life, Peiresc exchanged letters with individuals in Europe and the Levant, often for the purpose of obtaining news and information or requesting services. He transformed existing correspondence networks into a scientific information-retrieval system. Letters from Parisians Pierre and Jacques Dupuy, librarians to the king, provided news about the royal court and book fairs. At Peiresc's insistence, the Dupuys also gathered information of scientific activities from the Parisian circles. In his letter of February 12, 1628 to Pierre Dupuy, Peiresc juxtaposed a variety of topics—inquiries about historical inscriptions and astronomical issues—and expressed his hope to "learn at your convenience of the observation of the eclipse by Mr. Mydorge, Morin, and Des Hayes" (Tamizey de Larroque, *Lettres* 1: 529). In his weekly letter to the Dupuys of March 4, 1628, he included calculations of the difference in longitude between Aix and Paris and explained the need for verification of measurements:

> I am sending you a small account of the comparison of the observations of the eclipse that you were kind enough to send, with those [observations], which were made here, and with yet another made in Digne (although much less exacting), and from which, I am assured, you will

> take pleasure in seeing the wonderful consequence drawn from the difference in longitude of three and one half degrees between here [Aix-en-Provence] and Paris, and three quarters of a degree from here to Digne. (Tamizey de Larroque, *Lettres* 1: 548)

After providing these concrete results, he explained his need for additional information, requesting that an "exacting person" take these measures:

> I beg of you to see if Mr. Mydorge or some other gentlemen who take pleasure in mathematics has not done this, and if they would mind sharing it, if not persuade them to make them . . . in the presence of competent witnesses who are men of letters. (Tamizey de Larroque, *Lettres* 1: 548)

Peiresc not only sought information but specified the need for skilled and credible witness observers—"competent witnesses who are men of letters." In the absence of academic certification, competence was related to status, generally social position. By sending the Dupuys a copy of the positive results, he encouraged them to obtain needed data. He was also certain that his letter would be shared among scholars, who in turn would communicate these findings to their colleagues. Peiresc also explained that he had written two correspondents in Rome for information and had forwarded a letter from his friend and colleague, the cleric Pierre Gassendi, to Galileo concerning the data:

> I sent them the results of the comparison of the observations of Paris and of this city, and of the difference in longitude, to induce them to do as much for the locations from which the eclipse was observed. . . . I plan to do the same for Venice and Padua. (Tamizey de Larroque, *Lettres* 1: 548-49)

In this letter, Peiresc clarified the purpose—to "induce" others to obtain data from observers. He would ask cardinals to order Jesuit missionary priests to make observations throughout Europe and the Levant, which demonstrated his ties with powerful circles and plans to establish observation stations using priests trained in mathematics and astronomy. Peiresc and his colleagues also sent these observations of the lunar eclipse of 1628 to Galileo, in Italy; the astronomer Godefroy Wendelin, in Belgium; and the astronomer-cleric Wilhelm Schikard, in Germany (Tannery, de Waard, and Beaulieu 2: 29n). On May 2, 1628, Peiresc sent a letter to Lucas Holstenius, a geographer for whom Peiresc helped arrange a position in the papal entourage in Rome:

> I forgot to inform you that based on observations made in Paris and in this city of Aix of the precise time of the last lunar eclipse, which occurred this past January, we calculated the difference between the longitude of the meridian of Paris and of this city . . . to be three and one half degrees [between Paris and Aix], such that the meridian of Paris passes very close to that of Toulouse. And since I do not think that your interest in geography is limited to that of Greece . . . I thought that you would not be displeased to have this observation.
>
> We computed the difference in longitude of the meridian of Paris and of this city [Aix] . . . the observation of Paris was directed mainly by Sieur Mydorge, treasurer of France, an exacting man and versed in the most noble areas of mathematics, the Sieur des Hayes, Father Mersenne, Minim, the Sieur Morin, and others.
>
> Participants in this city [Aix] were the Sieur Joseph Gaultier, doctor of divinity, prior and seigneur of La Valette, grand vicar of the Archbishop of Aix, and the Sieur Gassendi, also doctor of divinity, theologian, and the present provost of the cathedral church of Digne, both good astronomers . . . and all my friends whom I convened for this experience. (Tamizey de Larroque, *Lettres* 5: 274)

The astronomical data in this letter came only in the postscript and followed a lengthy discussion about the recipient's research interests and news of book publications. In the first paragraph, he provided the results of observations and an explanation of their importance in practical terms (e.g., the proximity of the meridian to other cities). He justified sending these results by referring to Holstenius's interest in geography. In the second paragraph, Peiresc identified participants by title and, when appropriate, by expertise. Again, an individual contributed to his expertise, hence making claims appear more credible. By sending data to correspondents with connections in influential political and ecclesiastical circles, such as Holstenius in Rome, as well as to elite scientists, such as Galileo, Wendelin, and Schikard, Peiresc hoped to gain recognition and support for his work. In this letter to Holstenius, he did not describe materials and methods, as he would do for more competent astronomers, he instead focused on results and the pedigree of observers. The point of sending the results seemed not so much to establish priority, although a prize for a method of determining longitude was involved, but to induce others to follow this example and participate in upcoming observations.

Peiresc also relied on the support of cardinals to expand this project. Since his studies at the University of Padua (1599-1602) and visits to Rome, where he frequented ecclesiastical circles, he maintained contacts with cardinals through the exchange of gifts and information. He showered Cardinal Francesco Barberini with rare manuscripts, plants, and even a gazelle. Barberini, nephew to the future Pope Urban VIII, reciprocated with plants, manuscripts, and artifacts. Peiresc also used these connections with cardinals to arrange for patronage positions for his clients, or protégés, in the papal entourage, which improved his influence in these circles. Peiresc would later ask Barberini to have observations made by missionary priests, most of whom had training in the use of basic astronomical instruments. The recruitment of priests was vital to the success of this project, which required skilled observers at distant geographical locations. In the previous century, the Danish astronomer Tycho de Brahe (1546-1601) had been unsuccessful in attempting to have members of the diplomatic corps make observations throughout Italy. These individuals would not necessarily have had the needed skills to make accurate observations.

Peiresc had to contend with numerous unforeseen events such as weather and loss to pirated ships that disrupted his plans for work on longitude. But outbreaks of the plague forced him to retreat from Aix to his country home in Belgentier in 1629 and abandon his astronomical instruments. In one month, more than 1,500 people died in Aix. Civil unrest followed in Aix and other cities in the South of France when the crown filled local government positions with royal appointees, turning public opinion against people such as Peiresc, who held government positions or had ties with the crown.

Peiresc returned to Aix in September 1632. Encouraged by the positive results of the 1628 eclipse, he began organizing wide-scale observations for the lunar eclipse of August 28, 1635. At the time he began preparations, Galileo faced his own problems with the Inquisition, which would have some implications for Peiresc's need to recruit priests to make telescopic observations.

Galileo made public the theoretical justification for his support of the Copernican system. His *Dialogue Concerning the Two Chief World Systems* (1632) had been approved for publication by censors, but printing was halted within months. Galileo was ordered to appear before the Inquisition. On June 22, 1633, he was sentenced to recant his beliefs before the Inquisition, and the Copernican system was condemned as heresy. Although the Roman decree was not ratified by French theologians and hence enforcement in France was problematic, many scholars, such as René Descartes, worried about publishing their scientific works in a Catholic country, as Descartes expressed in a letter to Mersenne dated in early February 1634: "I wanted to suppress entirely the treatise that I had done and lose most of my work of the last four years to give obedience to the church as it prohibited the opinion of the movement of the earth" (Tannery, de Waard, and Beaulieu 4: 27).

Unlike those individuals who cautiously advanced science, Galileo claimed in his *Dialogue* that he proved the earth's mobility. Following the Injunction of 1616, most scholars spoke of the Copernican system as hypothetical, not real. Peiresc, too, was cautious in his approach. Instead of seeking to disprove tradition, Peiresc stressed the practical applications of astronomy: the determination of longitude of contemporary and historical cities and the prediction of church feast days, which were based on the lunar cycle. He also gained the support of Roman Catholic cardinals in organizing observations and, in 1635, wrote that Cardinals Barberini and Bagni asked priests to participate in observations for work on determining longitude (Tamizey de Larroque, *Lettres* 4: 529).

Although in a series of letters Peiresc attempted to persuade correspondents to observe the lunar eclipses of April 8, 1633, March 14, 1634, and March 3, 1635, the number of individuals who actually complied is unclear. For the upcoming lunar eclipse of August 28, 1635, Peiresc sent telescopes and detailed instructions to correspondents in Egypt, Syria, Lebanon, and Tunisia. He asked Jean Magy in Cairo to give a telescope to a competent observer and show priests the sunspots and lunar mountains, a means of creating interest in astronomy and cautiously refuting the more traditional opinion of immutable heavenly spheres. He told priests that "the book of Nature is the book of books, and there is nothing so conclusive as the observations of things . . . where the greatness of God appears" (Tamizey de Larroque, *Lettres* 7: 856-57). This argument, also used by Galileo, could manipulate readers and justify astronomical observations at a time of ecclesiastical censorship and the Inquisition.

In other letters, Peiresc asked correspondents to contact local Jews and Arabs known for their skills in cartography and astronomy. Many of these correspondents would comply because they were seeking positions with cardinals with whom Peiresc maintained close ties; others hoped to improve their status in the scientific community. Others cooperated because their acceptance of Peiresc's gifts, which included rare and prestigious astronomical instruments, implied an obligation to reciprocate.

Peiresc adapted his arguments to the recipient. For some, a rational appeal (e.g., practical application) might elicit a response rather than would one designed to appeal to clerics. He attempted to reassure other participants by reminding them that astronomical observations would not compromise their obligations to the church, or he explained that the study of nature, created by God, provided a means of learning more about its creator.

THE LUNAR ECLIPSE OF AUGUST 28, 1635

Preparation for observations of a lunar eclipse took place in numerous stages. Peiresc sent instructions and instruments to correspondents and organized hands-on training for area residents. For several months in 1634, Peiresc patiently supervised observations made by his bookbinder, Simon Corberan, and asked that the cleric-astronomers Gaultier and Gassendi compare these observations with their own and assist in the calibration of instruments. Peiresc also tried to persuade the Tunisian resident Thomas Arcos to observe the eclipse so that he could include measurements of latitude and longitude in his planned publication on Africa. On January 25, 1634, Peiresc discussed musical instruments and weights and measures before requesting that Arcos engage people to make observations:

> I would like to have this observation [altitude] made several times, mainly at the longest and shortest days of the year, to determine the true latitude or elevation of your location, which is missing from your *Account of Africa*. . . . And if, with the help of those people or others, you could make an accurate observation of the next eclipse of March 14, around 4 in the evening, that would be a good means to determine the longitude of Tunis; as this [eclipse] will be observed, weather permitting, in Rome and various regions of Europe by great astronomers who would be pleased to include your observation with theirs. (Tamizey de Larroque, *Lettres* 7: 119-20)

The amount of work Peiresc requested of his correspondents must have seemed overwhelming. Each observation station needed to provide measurements of the solstices in June and December. Furthermore, timepieces needed to be calibrated days in advance of an eclipse, both by the altitude of the sun and that of the fixed stars. Time and altitude needed to be recorded continuously during the progression of the eclipse.

In this letter, Peiresc stressed how these observations would add value to Arcos's book. To persuade Arcos to carry out these observations, Peiresc used various strategies, such as pointing to the usefulness of determining the meridian of Tunis and to the possibility of achieving personal status by contributing to this endeavor in which the "great astronomers" would participate. After indicating the anticipated time of the eclipse in Rome, Peiresc provided specific instructions for observations:

> To indicate the moment of the hour, as much the beginning as the end or half way point of the eclipse, you must have a rather large instrument, either a quadrant or other [instrument] to take the height of some visible fixed star not too close to the horizon nor too close to the meridian or vertical [axis] so that the progress of the difference in time of its movement during the eclipse is more apparent and visible. There must be various people so that one takes the height of such a fixed star at the same time that another observes the moon beginning to eclipse, and the same for the end and the mid point . . . if you could estimate even with the naked eye the finger's width of the portion of the lunar disk that is eclipsed and not eclipsed to convince others of the truth of the time of the eclipse, and as a result of the location of the city of Tunis, which would bring great recognition to your *Account of Africa.* You only need a large quadrant divided into 90 units with sights on one side to view the star and a plumb line to indicate the degrees. (Tamizey de Larroque, *Lettres* 7: 119-20)

In a subsequent letter of August 3, 1634, Peiresc thanked Arcos for the gazelle sent from Africa, explaining that he was too "insignificant" to keep such an animal worthy of a prince. He then proceeded to express his disappointment that his instructions on the eclipse arrived too late to be of use. Again, he reiterated his need for measurements made during the solstice:

> Because if you had observed, we could use these [data] to verify if Carthage or Tunis is on the same meridian as Rome; and if you could observe the true altitude of the noonday sun during the two or three days of the solstice either in winter or summer, that would be a great service to the public and the curious. (Tamizey de Larroque, *Lettres* 7: 133)

Peiresc and Arcos had maintained a long-term correspondence, exchanging both news and small gifts. Arcos, a former secretary to a cardinal, recently had converted to Islam—to Peiresc's dismay—but continued to provide curiosities from North Africa. Arcos might have been one of the few contacts in Tunisia as Peiresc continued to beseech his participation in the longitude project. Not only did Peiresc explain how such observations would benefit Arcos personally in the reception of his book, but he provided additional incentives, stressing the contemporary and historical value in determining longitude.

Peiresc wrote again on April 29, 1635 and May 11, 1635. He included a quadrant and described its use; he warned of distortion occurring with naked-eye observations. Telescopes eliminated the haze, which made objects appear closer and larger than they actually were. But Arcos continued to provide numerous excuses as to why he could not participate. Because Arcos had converted to Islam and lived at a distance from France, Peiresc could neither persuade nor manipulate him.

The placement of numerous observation stations could reduce the source of errors by providing verification in case some observers experienced bad weather or introduced human error. One set of data would not suffice. Peiresc worked to establish other observation stations in the Levant. He asked missionaries in Egypt to make observations, explaining in a letter of 1635 that such an endeavor would bring "honor and benefit" to their missions and enable a comparison with astronomer Ptolemy's calculations, dating from the second century AD (Apollinaire de Valence 137). On May 17, 1635, he specifically asked Father Agathange de Vendôme in Cairo for observations of the main phases of the eclipse, and he explained how to calibrate timepieces prior to the eclipse and how to measure the altitudes of the fixed stars and the moon during the eclipse:

> You must not only rely on the naked eye. It is necessary to use the so-called short telescope . . . to see the body of the moon stripped of its extraneous rays because with the naked eye, the illuminated part appears much larger than it is in fact. . . . If you could indicate precisely the time of the beginning of the aforementioned eclipse and that of the total obscurity of the lunar sphere, and that at which the light returns, these are the main points or moments most able to provide a basis for the conclusions that can be drawn. . . . The question is to be able to indicate the time by timepieces that are so well calibrated that we can establish them [and longitude measures] with certainty. But it would be better and more indisputable if you could have some instrument by which to indicate the altitude of some fixed stars in the east and west rather high above the horizon. . . . Because with this we can make calculations of the exact moment at which you observed, the time of your eclipse, and consequently the distance of your location and those [sites] of Christianity. . . .

> And for the beginning of the eclipse, it would be good to take also the elevation of the lunar sphere, to take it by above or below. But you need to indicate with which eye you observed, if that would be the left or right.... You will have this eclipse two hours earlier than we [do].... It would be very good to have observed the altitude of the noonday sun, using a quadrant days before the eclipse and the day of it, and following. And if you would have observed several days before at noon, at the time of the summer and winter solstice. (Apollinaire de Valence 137-40)

These letters showed Peiresc's preoccupation with consistent and controlled observations and his emphasis on a standardized method, which included the calibration of timepieces several days in advance and attention to details that could introduce errors into data. In the first section of the letter, he explained the need to observe with a specific instrument and the errors that occurred with naked-eye observations. Peiresc also described why instruments should be preferred over naked-eye observations. When telescopes were first introduced to view the heavens by Galileo (1610), many clerics assumed they distorted rather than enhanced the senses.

In the previous letter, Peiresc advised the use of the short telescope, likely the Galilean, which consisted of a concave lens at the objective and a convex lens near the object. This telescope had a limited field of view and did not enable viewing the entire lunar body. The astronomical telescope with two convex lenses had a larger field of view and increased magnification, but it also inverted the image. This telescope gained in use only in 1645 (Van Helden, "Telescope" 43-44).

Then, Peiresc described the three phases of the eclipse, which needed to be observed. He stressed that the observational data would "provide a basis for the conclusions." Unlike the traditional practice of science, where conclusions were drawn from Aristotelian principles or the scriptures, Peiresc wanted solid evidence to support his findings. His choice of words indicated his desire to establish claims as indisputable and credible. To achieve this credibility, he asked again to calibrate timepieces and to verify time by measuring the altitude of a star. Furthermore, he offered various incentives to persuade—gifts or the promise of patronage, the contribution of the activity to public welfare, or a means of learning about God through His works and the location of ancient sites of religious value.

Accompanying this letter of May 17, 1635 to Father Agathange de Vendôme, Peiresc included instruments, both telescopes and quadrants, and a copy of instructions (Apollinaire de Valence 138-40). In less than two weeks, he wrote again to the priest in Cairo, explaining his fear that his previous letters might have been intercepted by the Spanish navy. This time (May 28, 1635), he included another set of instructions and reiterated his desire for observations to be made from a pyramid (141). The priest responded (July 25, 1635) that this venture was not possible because of thieves lurking in the area and the steep climb (154).

In many cases, requests for information followed a lengthy exchange of gifts. Father Agathange de Vendôme had sent holy relics from Cairo; Peiresc reciprocated with Arabic dictionaries. He demanded observations from correspondents, many of whom were obliged to him for arranging patronage positions and financial support.

Peiresc also wrote the scholar Gabriel Naudé in Rome (June 28, 1635) to ask local astronomers and mathematicians to observe. To enhance the quality of future observations, Peiresc also engaged an artist to sketch the lunar topography during the phases of the eclipse, which would enable more precise viewing of the exact portion of the lunar disk covered by the earth's shadow.

For the observations in Aix, Peiresc coordinated numerous activities. Antoine Agarrat, Peiresc's secretary and a skilled astronomer, manipulated a large quadrant and noted altitudes of fixed stars. Another person also marked altitudes and described the phases of the moon. Two other observers verified observational data with other telescopes. Although Peiresc carefully coordinated these observations, he encountered numerous problems. The stars that were needed to determine the local time of the eclipse were not visible; the three men sent to a mountain to observe fell asleep during the beginning of the eclipse. Clouds interfered with Gassendi's viewing in Digne. Following the observation, Gassendi wrote that they "absolutely cannot trust [astronomical] tables, either for the precision of movements or for the difference in longitude"(Tamizey de Larroque, *Lettres* 4: 534-35, 544). Improved accuracy of tables of planetary movements was critical to determining the time of the eclipse, which would facilitate setting up observation stations. In the meantime, Peiresc needed to obtain firsthand observations to correct astronomical tables.

THE COLLECTION OF DATA

In September 1635, Peiresc wrote several times to Egypt, reminding priests to provide data that would enable the determination of distances between Aix, Paris, Rome, and Cairo. In the postscript, he requested measures of the latitude of Cairo and Alexandria, especially measurements of the noonday sun at the solstice and of the north star above the horizon, stressing that these measures, which had not been taken since the time of Ptolemy, could serve future generations and aid in determining the date of Easter (Apollinaire de Valence 188). The importance of new observations was obvious. Ptolemy's measurements dated from centuries earlier.

In late October 1635, Peiresc had received only those observations from Paris and a Jesuit in Rome. Again, he reminded participants of their obligations and inquired if they had indeed received the gifts accompanying his requests (Apollinaire de Valence 171). The acceptance of these tokens implied the obligation to provide the needed service. By November, he had received most observations from Italy and France.

Writing again to Father Agathange de Vendôme on December 24, 1635, Peiresc explained that he had just received a letter dated in September informing him of the illness of mission priests at the time of the eclipse. Although this news "greatly distressed" him, Peiresc was far more concerned about the loss of data, and he reminded de Vendôme of his pressing need for observations and urged him to obtain this data from other priests who observed:

> [The priests] had some scruples about sending me the copy, under the pretense that there might be some small ambiguities or that it [observation] was not carried out and calculated as precisely as needed. . . . I have written the Reverend Father Michelange to beg him, and I have decided to ask you to intervene in my behalf, and to tell him that he should not hesitate to write promptly about his observation, just as he noted it, with the same doubts and questions that he believes to have committed: because I can use this information to my benefit. . . . And if you can include another observation of the two upcoming lunar eclipses of February and August, and some observations of the height of the noonday sun during the next days of the solstice, nothing more will be needed to determine the calculation of the true distances . . . and the relationship with those determined by Ptolemy, Hipparchus, and other ancients: as such future generations will be obliged to you and your religious order. (Apollinaire de Valence 214-15)

Peiresc concluded this letter, mentioning that he had written Barberini about the priest's contribution to the longitude project, an obvious allusion to the priest's need to reciprocate. Peiresc also alternated in this letter between concern and pragmatism. After express-ing his dismay over the priests' illness and recognition of reasons participants might be reluctant to send data, he quickly introduced the main point of his correspondence—to obtain the observational data. He pointed out that because de Vendôme had not observed firsthand, he should acquire the information from other sources. Again, Peiresc used rational appeals to persuade—the recognition brought to the mission and the contribution to history and church calendar reform. Then, he mentioned that he had written to Barberini about the priest's work. The message was clear: Peiresc implied that because he had written about the priest in positive terms to Barberini, the priest should reciprocate and obtain the data.

Collecting and collating data to determine the difference in longitude were fraught with problems due to mail delays, reluctant participants, and missing information. In addition to soliciting the help of a priest in obtaining data from Egypt, Peiresc wrote a mission superior at Aleppo to intervene and obtain the needed data. These efforts continued for nearly 18 months until Peiresc finally received some of the data in January 1637. Some observations from correspondents were carelessly recorded; some data from Cairo and Aleppo lacked measures of the altitudes of the fixed stars that were needed to determine local time. Other data did not include the names and titles of witnesses needed to establish the credibility of claims. Nearly a year after the eclipse of August 28, 1635, Peiresc continued to ask priests to produce the data even if they had "some suspicion of mistaking one star for another or one degree for another on [their] instruments" (Apollinaire de Valence 216-17, 257).

Arcos had not participated in these observations, claiming he was too old and unskilled, yet reminded Peiresc of the other services he had rendered. Peiresc argued that observations would enable the determination of the difference in longitude of Tunis and Carthage and the location of the ancient Battle of Arabella said to have taken place during a lunar eclipse. In other letters, he noted that even gardeners and artisans had undertaken such observations and urged Arcos to make observations of upcoming eclipses (Tamizey de Larroque, *Lettres* 7: 163-64, 170-79). His use of numerous strategies to persuade—gifts, enhanced value of publication, and participation of unskilled observers—did not provide sufficient incentive.

While soliciting information from some, Peiresc attempted to identify sources of error with others. He asked participants to describe their methods of observation: how they took altitude, whether they viewed with the left or right eye, what type of telescope they used. He maintained that these variables could introduce bias into results. Despite Peiresc's emphasis on the need for firsthand observations, some information was copied from existing astronomical tables (Tamizey de Larroque, *Lettres* 4: 559).

Even competent astronomers made mistakes. Peiresc found that André Argoli in Italy had data incompatible with his published astronomical tables, which might have explained his hesitation in sending his observations. Camille Glorioso, reputed to be second only to Galileo in Italy, omitted essential information and did not make sufficient measures of the altitude of fixed stars needed for the determination of local mean time. Peiresc wrote his colleague, the cleric-astronomer Gassendi, about these concerns: "These inconveniences by the skilled people show the need to print a small booklet . . . that would provide the most basic skills needed to observe" (Tamizey de Larroque, *Lettres* 4: 579-80). A printed booklet could expedite the organization of observation stations and standardize observational procedure. Although Peiresc asked Gassendi to write the booklet, another colleague, the cleric-astronomer Joseph Gaultier, would later undertake this project.

Even though Peiresc encountered numerous difficulties in obtaining reliable data, the observations of the lunar eclipse of August 28, 1635 provided practical applications such as the difference in terrestrial longitude of numerous cities. Furthermore, Peiresc and his colleagues discovered the length of the eastern Mediterranean Sea to be approximately 1,000 kilometers shorter than shown on existing maps. The success of this endeavor would engender new adherents and lead to other projects such as selenography, or mapping of the topography of the moon, to enable more precise viewing of the lunar eclipse.

OTHER ASTRONOMICAL WORK

Peiresc also worked on observations of the noonday sun at the solstice for the determination of latitude and for church calendar reform. The church needed to date Easter years in advance to allow time for preparations for worldwide celebrations. One method used to determine Easter was by marking the image of the noonday sun along a meridian, or north-south line, embedded in the floor of a dark church. A hole pierced in the roof of the church enabled a few minutes of light to penetrate at noon and to project on this line over the course of a year. Divisions marked on the meridian indicated the daily position of the sun and the precise number of days between the equinoxes.

Peiresc planned to adapt the meridian installation to the Church of the Oratorians in nearby Marseilles. He had a hole pierced in the roof and then had constructed what he described as a large sundial 36 meters in diameter with a gnomon, or stele, 18 meters high. Making measurements of the solstice was not enough. Peiresc also wanted to compare his results with those obtained 2,000 years earlier by the navigator Pytheas. To this end, he acquired a scale drawing and the measurements of an ancient stele from Holstenius, who studied early navigators and geography (Tamizey de Larroque, *Lettres* 7: 181, 5: 447).

Peiresc also sought to improve the handling of instruments and hence eliminate additional sources of error. With the help of Gassendi and Gaultier, Peiresc attempted to standardize procedure by establishing a training program in telescopic observations to instruct priests prior to their departure for missions in the Levant. Peiresc had instructions published on the use of instruments, and he initiated a project in selenography for which he hired the engraver Claude Mellan. Mellan completed three plates of the phases of the moon during an eclipse. But Peiresc's death on June 24, 1637, brought a halt to these activities.

Investigations of longitude continued under the auspices of the Paris Royal Academy of Sciences (1666). Giovanni Domemico Cassini published the tables of the Jovian moons in 1668, and he arrived in Paris the following year to begin correspondence with observers who could provide data from other geographical locations. Cassini's instructions to other observers reiterated many of the concerns of Peiresc—the calibration of timepieces, measurements of altitude, and the need for consistency (Van Helden, "Longitude" 95-96). Although astronomers continued to use eclipses of the Jovian moons for the determination of terrestrial longitude, the question of longitude at sea would only be resolved in the following century with a perfected timepiece developed by James Harrison in 1755 and tried at sea in 1761 and 1764.

ANALYSIS

In a period of censorship and the Inquisition, Peiresc advanced scientific investigations by stressing practical applications. Whereas Galileo attempted to prove the earth's mobility despite the church prohibition, Peiresc enlisted the support of the church in the determination of terrestrial longitude and in church calendar reform. The success of these undertakings depended on Peiresc's ability to communicate persuasively. This section provides an analysis of the communication strategies, such as the methods to persuade individuals to comply with requests, efforts to standardize materials and methods, and techniques used to gain recognition for results.

Work on a method of calculating terrestrial longitude brought together people of diverse backgrounds, affiliations, and skills. Although society allowed little mobility, the scientific community rewarded members on the basis of competence and ability to provide information from various locations. Peiresc perfected various strategies to solicit help in observations, acquire data, and gain acceptance for his findings. He offered gifts and patronage to those who followed an observational protocol. Gifts such as instruments or rare manuscripts brought status to recipients beyond that associated with their professions. But the acceptance of the gift implied the obligation to comply and provide information; refusal to comply could result in the loss of status or disgrace in the scientific community. Reward was not limited to tangible objects. Having close ties to the church, Peiresc could arrange patronage positions, which provided status, financial security, and protection. He secured a position for the geographer Holstenius in Rome, and he sought positions for priests and scholars who helped in organizing observations. The placement of these individuals in patronage positions served two purposes: It strengthened Peiresc's connections to Rome and obliged his protégés to carry out his requests. He also gave others, such as Corberan and Arcos, opportunities to succeed.

The promise of reward did not always guarantee results. Exchanges with Arcos showed the limits of persuasion. For years, Peiresc exchanged letters and gifts with Arcos, who had served as secretary to a cardinal prior to his capture by the Turks. But Arcos remained in Tunis after his release and had converted to Islam. He seemed uninterested in specific rewards such as status conferral and could not be moved by coercion and the possibility of losing Peiresc's support. When Arcos pleaded ill health, old age, and inability, Peiresc insisted that even unskilled individuals had undertaken such observations. Although Arcos provided numerous excuses for not fulfilling the requests, he sought to maintain Peiresc's friendship by sending unique gifts.

Patronage and gift giving were also forms of social control. When information was not forthcoming, Peiresc made the obligation clear, asking if correspondents had indeed received the gifts. The priest Michelange de Nantes never responded directly and did not show an interest in advancement. The promise of reward left some local observers unmoved. One cleric refused to come; several assistants fell asleep.

Although many individuals complied because of the promise of reward, others may have felt constrained to participate due to the veiled threat of the withholding of reward. Just as Peiresc would mention the willingness to perform services, he could also withhold recognition. He wrote to a mission superior; he could make recommendations for appointments.

Patronage and gift giving became an integral part—probably the most persuasive strategy—in perfecting the technical work on a method of longitude. Peiresc provided a research program, connections to influential circles, and funding. The successful acquisition of information was a function of his tenacity and use of persuasion and manipulation.

Peiresc's ties with ecclesiastics and royalty gave him the authority to organize scientific investigations. He established a reputation through his ability to find practical applications for scientific discoveries and to organize investigations. Peiresc adapted his arguments to individual participants and used rational appeal. Precise tables of planetary movements and accurate observations of the sun's movement along a north-south meridian would enable the church to date Easter with precision. Astronomical observations could reveal more about the world created by God without compromising obligations to the church. Peiresc wrote to others about the historical significance in comparing recent observations to those made centuries earlier. He told Arcos that measurements of longitude and latitude would make his work on Africa more valuable.

Although the church and crown tended to deny legitimacy of the new science because of the threat it posed to their authority, the scientific community provided a context for recognition and advancement. Once observations were made and data were collected and collated, Peiresc, Gassendi, and Gaultier prepared a scientific report, which involved the comparison of data, verification of observations, requests for additional measurements, and clarification of procedures. Peiresc included the names and titles of witness observers. But the social status and competence of the observer did not guarantee the uncritical acceptance of data, as in the cases of the Italian elite astronomers Glorioso and Argoli, who omitted data and measurements from their observational results.

With the shift from the traditional authorities of Aristotle and the scriptures to that of the individual observer, Peiresc needed to establish criteria by which evidence could be evaluated. He insisted that observations follow standardized protocols; he provided hands-on training and planned to distribute a printed instruction booklet. The moon-mapping project would add precision to observations. For the results to gain recognition as plausible, he attempted to re-create the experience of the observation by narrating the chronology of events before and during the eclipse and including the names and titles of participant witnesses and sending this information through correspondence networks. The concrete findings provided the needed legitimacy for scientific activity and social recognition for its practitioners, which induced others to participate. Finally, the format of the scientific argument shifted from an earlier emphasis on claims proceeding from the first principles of Aristotle and the use of rhetorical structure to claims founded on observation, inquiry, and demonstration. Unlike Galileo, who attempted to use astronomical observations to promote a new worldview, Peiresc avoided controversy to advance science with the blessings of the church.

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