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Colonial Astronomers and the Transit of Venus

An Exemplar of American Enlightened Thinking

Kelly A. Harrison

Stanford University

The transits of Venus in both 1761 and 1769 were immensely important in the history of science. Although people in the British Colonies, because of Earth's position, were unable to view the transit in 1761, the 1769 transit gave colonists the opportunity to participate in a global scientific endeavor by recording their observations, the data from which helped mathematicians calculate the distances to both the Sun and Venus and thus calculate the size of the solar system. Natural philosophers, community leaders, scholars, and others with interest in astronomy collaborated on the viewings and eagerly sent their data to the Royal Society in London. The many observations of the 1769 transit event in the colonies provide evidence of both "the links that tied Europe and the Americas together"[1] and colonial "enlightened" thinking and reasoning connected with empirical data collection and scientific progress.

One of those links between Europe and America is, of course, Benjamin Franklin, who passed information about the transit back and forth across the Atlantic. In 1769, the American Philosophical Society, an organization started by Benjamin Franklin to mirror the Royal Society of London, funded £100 to three observation teams for the 1769 transit: One in Philadelphia, another in Norriton 20 miles from Philadelphia, and a third at Cape Henlopen, Delaware. The APS published the results of these

[1] Caroline Winterer, *American Enlightenments: Pursuing Happiness in the Age of Reason* (Yale University Press, 2016), 11.

observations and others in their *Transactions* in 1771, and these were republished in the *Philosophical Transactions of the Royal Society* in London. Both organizations had members in common who communicated regularly across the Atlantic to share scientific knowledge. The documents produced by the APS-sponsored observations can instruct us in how the colonists participated in one of the first global acts of collective scientific study.

In particular, we examine here a small group of men who organized three telescopes and assistants in Norriton, Pennsylvania, at the farm of David Rittenhouse, where Rittenhouse had already planned an observatory in anticipation of the transit. These men chronicled their efforts through narrative, recorded detailed data, and later calculated the Sun's parallax to a much higher degree of accuracy than was acknowledged at the time. In this singular effort we find an example of the enlightenment ideals of empirical evidence, applied reasoning, and progress in expanding knowledge. To understand the significance of these efforts, we first need some context around how Britain handled the first transit.

Britain Fails in 1761

Unlike Russia, France, and Sweden, Britain largely failed to record the 1761 transit, even when accounting for the fact that astronomers the world over struggled to accurately record timings because of effects of the atmosphere of Venus. Mason and Dixon, in Cape Town, studied the transit in perfect weather conditions, their observations being "the only satisfactory report from the Southern Hemisphere."[2] Not so lucky was Maskelyne who, unfortunately beset by bad weather, witnessed the transit "occasionally" but recorded nothing useful. Another bit of luck for the British came from America; even though the transit wasn't visible in the American Colonies, John Winthrop of Harvard offered a second British success because he journeyed to Newfoundland on a trip funded by the Province of Massachusetts Bay.[3] His subsequent lectures influenced the colonists to prepare for 1769. In the end, though, any British success in 1761 was offset by larger losses.

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[2] Sheehan and Westfall, John, *The Transits of Venus*, 153.

[3] Harry Woolf, "British Preparations for Observing the Transit of Venus of 1761," *The William and Mary Quarterly* 13, no. 4 (1956): 501, https://doi.org/10.2307/1917021.

The number of British total observations stands in contrast to those of the French (see Table 1), and whereas the vast majority of British work was done in London and Greenwich, the French spread their telescopes around France, increasing their chances of good weather. The French and others had their share of problems with observations and expeditions, but the British were supposed to be the leaders in astronomy, yet they had fewer successes than the Swedes. Given the British struggles to get observers to locations and to deal with the weather, the British, perhaps as a consequence of national pride or international shame, immediately started planning for the 1769 transit because they didn't want to lose either their literal war against the French or the scientific one.

Table 1. Numbers of transit observations in 1761 by country, collected by Encke[4]

Country	Observations	Foreign
France	31	4
Sweden	21	5
Britain	19	5
Russia	3	0

Joining International Efforts

After the 1761 transit, many countries, in addition to Britain, increased their funding and research efforts for the 1769 event, with "waves of popular interest" around the event.[5] King George funded the full £4,000 requested by the Royal Society of London. Although the King's funding supported dozens of expeditions, none of that money was sent to the colonies nor was it used to send any English astronomers to the colonies. This oversight is quite surprising given that the British needed as much help as they could get to restore their stature in the scientific world. The British did, however, try to send an expedition to Mexico. According to a letter sent by Don Georges Juan of Spain to French mathematician and explorer Charles Marie de la Condamine, the British had asked for

[4] Woolf, *The Transits of Venus: A Study of Eighteenth-Century Science*, 135–40.

[5] Woolf, 150.

permission to send a team to California, but they were refused,[6] whereas the Spanish then invited the French to Mexico, and Abbé Chappe d'Auteroche traveled to San Jose del Cabo, making some of the most-detailed and important transit observations before dying there, likely of typhus.[7] In the second transit, Britain and France both outpaced Russia and Sweden in total number of observations (see Table 2), but with the additional 18 observations in the American colonies, Britain alone had more observations than the next three countries combined. Essentially, America helped restore British dominance at the same time it put itself on the world map for scientific knowledge and skill.

Table 2. Numbers of transit observations in 1769 by country[8]

Country	Observations
Britain	68 (18 in American colonies)
France	34
Sweden	15
Russia	13

The members of the American Philosophical Society wanted to join international efforts, but on their own terms. For international outreach, they offered honorary membership to key scientists throughout Europe, and Franklin wrote to people like William Smith, encouraging them to come to America to teach. As for the transit events, despite several urgings from Britain (relayed through Franklin) to send a trip to Lake Superior, the colonists instead funded at least 18 observations, and their results were shared with others in England and France by Franklin, William Smith, John Ewing, and others, with the observations at Norriton being judged as "on par with those of the Royal Society in London."[9] One concrete piece of evidence illustrating an

[6] Woolf, 157.

[7] Sheehan and Westfall, John, *The Transits of Venus*, 196.

[8] Woolf, *The Transits of Venus: A Study of Eighteenth-Century Science*, 182–87.

[9] Brooke Sylvia Palmieri, "American Philosophical Society," Encyclopedia of Greater Philadelphia, 2016, https://philadelphiaencyclopedia.org/essays/american-philosophical-society/.

understanding of the international importance of the work comes from William Smith:

> For I am persuaded that the dependance [sic] which the learned world will place on any particular transit account, will be altogether in proportion to the previous and subsequent care, which they find hath been taken, in a series of accurate and well-conducted observation, for regulating the time-pieces, and ascertaing [sic] the latitude and longitude of the place of observation, &c.[10]

Smith articulates the connection between the "care" and accuracy demonstrated in recording every aspect of the transit as a reflection of how scientifically precise, and thus important, any observations would be judged by "the learned world."

Collecting Narratives, Data, and Lists

In contrast to the European observations, the colonial observers wrote narratives alongside their observations to a far greater extent, perhaps as a way to record a richer history more connected to "rational" human enterprise. The Royal Society's *Transactions* published a range of observations in full or in excerpts and exchanged those with Franklin's APS, which published its own articles sent to London for inclusion in the Royal Society's publication. With just a cursory look at a range of transit documents, we see that the American publications contain more personal narrative as well as more detailed lists of numbers, tables of data, and drawings.

For example, in Smith's account, which includes Lukens' and Rittenhouse's personal accounts, we see context and memoir included.

[10] William Smith, "Account of the Transit of Venus Over the Sun's Disk, as Observed at Norriton, in the County of Philadelphia, and Province of Pennsylvania, June 3, 1769. By William Smith, D. D. Provost of the College of Philadelphia; John Lukens, Esquire, Surveyor-General of Pennsylvania; David Rittenhouse, A. M. of Norriton; And John Sellers, Esquire, One of the Representatives in Assembly for Chester County; The Committee Appointed for ... Author(s): William Smith, John Lukens, David Rittenhouse, John Sellers, Doctor Smith and Nevil Maskeline Source: , Vol. 59 (1769), Pp. 289-326 Published by: Royal Society," *Philosophical Transactions (1683-1775)* 59 (1769) (November 23, 1769): 290.

Smith writes that he wants to "do justice to Mr. Rittenhouse" for his "extraordinary skill," and then he addresses "the learned and curious," saying he includes all this detail so that the reader may "conclude for themselves."[11] Smith provides a narrative of how the APS funded and supplied the groups, including telescopes and equipment borrowed or donated, such as copies of Maskelyne's how-to manuals given by Thomas Penn, a local businessman, and later a telescope that Penn asked be donated in his name to the College of Pennsylvania. Smith runs through events chronologically, including distances, weather, and the personal, such as the expression here of an implied pride and gratitude toward Rittenhouse:

> As Mr. Rittenhouse's dwelling at Norriton is 20 miles N. W. of Philadelphia, our other engagements did not permit Mr. Lukens, or myself, to pay much attention to the necessary preparations; but we knew that we had entrusted them to a gentleman on the spot, who had, joined to a complete skill in mechanics, so extensive an astronomical and mathematical knowledge, that the construction, use, and management of all the necessary apparatus are perfectly familiar to him. The dull and rainy weather prevented our setting out for his house till Thursday, June 1; and we found, on our arrival there, every preparation so forward, that we had little to do but to examine and adjust our respective telescopes to distinct vision.[12]

Details like distance to travel, acknowledging busy lives and the need to prepare, and referring to the character of your colleague are not seen in European accounts, and whereas weather is almost always referred to as meteorological observations limited to the measurable (wind, temperature, etc.), here the weather has personality—"dull." Similarly, in Owen Biddle's account at Cape Hinlopen, he writes that he and Joel Bayly "immediately set about fixing our time-piece, in a house (which we hired) on the south street of the town,"[13]

[11] Smith, 290.

[12] Smith, 294.

[13] Owen Biddle, Joel Bailey, and Richard Thomas, "An Account of the Transit of Venus over the Sun, June 3d, 1769, as Observed near Cape

giving us not just the detail of where in town they worked but that they rented a house. Such details are never shared by the English.

Furthermore, in the Norriton account, Rittenhouse also relates details not typically seen in other accounts of observations:

> Early in November, 1768, I began to erect an observatory, agreeable to the resolutions of the American Philosophical Society; but, through various disappointments from workmen and weather, could not complete it till the middle of April, 1769. I had for some time expected the use of an equal altitude instrument from Philadelphia; but finding I could not depend on having it, I fell to work and made one, of as simple a construction as I could contrive.[14]

This account reads like a story unfolding before the reader's eyes. He's looking to please the APS by adhering to their standards, but he encounters "disappointments" that delayed him. Where many might end there, Rittenhouse provides two reasons, weather and workmen, and then when he uses his faculties to reason through the entire project, he realizes a delay so serious he responds by designing and building his own solution. In such a short excerpt, Rittenhouse exhibits enlightenment thinking on many levels, from accuracy and care in construction to time management and planning to ensure progress is made.

We need examine only two representative samples to see that these details are not included in other reports. First, Jeremiah

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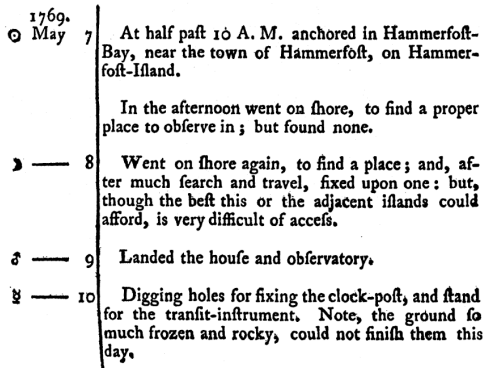
Henlopen, on Delaware. By the Committee Appointed for That Observation. Drawn up and Communicated, in Behalf of the Committee, by Mr. Owen Biddle," *Transactions of the American Philosophical Society* 1 (1769): 414, https://doi.org/10.2307/1005005.

[14] Smith, "Account of the Transit of Venus Over the Sun's Disk, as Observed at Norriton, in the County of Philadelphia, and Province of Pennsylvania, June 3, 1769. By William Smith, D. D. Provost of the College of Philadelphia; John Lukens, Esquire, Surveyor-General of Pennsylvania; David Rittenhouse, A. M. of Norriton; And John Sellers, Esquire, One of the Representatives in Assembly for Chester County; The Committee Appointed for ... Author(s): William Smith, John Lukens, David Rittenhouse, John Sellers, Doctor Smith and Nevil Maskeline Source: , Vol. 59 (1769), Pp. 289-326 Published by: Royal Society," 296.

Dixon's journal, one on the sparse side regarding details, tersely provides never more than a couple of points for each day, with month, day, and event listed as a table (see Figure 1).[15] He describes "a most violent storm of wind, hail, and snow" but then five days are collectively described as "cloudy, snow &c."[16]



1769.

☉ May 7 At half paſt 10 A. M. anchored in Hammerfoſt-Bay, near the town of Hammerfoſt, on Hammerfoſt-Iſland.

In the afternoon went on ſhore, to find a proper place to obſerve in; but found none.

☽ — 8 Went on ſhore again, to find a place; and, after much ſearch and travel, fixed upon one: but, though the beſt this or the adjacent iſlands could afford, is very difficult of acceſs.

♂ — 9 Landed the houſe and obſervatory.

♃ — 10 Digging holes for fixing the clock-poſt, and ſtand for the tranſit-inſtrument. Note, the ground ſo much frozen and rocky, could not finiſh them this day.

Figure 1.
Jeremiah Dixon's journal, listing only key points each day.

Second, the observations of William Wales and Joseph Dymond, who were sent by the Royal Society to Hudson's Bay, begin with no formalities; they describe where and how a thermometer was hung, followed by sixteen pages of observation data in tables. In the later remarks, though, we get the closest to any narrative with details like those in the American reports. Wales writes about a broken compass:

> As the cold was, by the time that we made this discovery [of the broken compass], much more intense than it probably was at the time that Mr. Ellis complains of a similar circumstance happening to him in those parts, I was naturally led to try whether I could not benefit by his experience, and accordingly removed the compass into the room where we lived; which was kept very warm by a large fire, and by the house stove; and there it remained ever after, but without the least effect. In order to remedy this misfortune as much as lay in

[15] "Observations Made on the Island of Hammerfost, for the Royal Society. By Jeremiah Dixon," 253.

[16] Ibid, 255.

> my power, I applied to Captain Richards, as soon as he arrived in the river this year; and desired he would send me his azimuth compass on shore, with which request he very kindly complied the next day; but the cloudy weather prevented me from making any observations before the 22d of August.[17]

This excerpt is notable for implying the importance of narrative, that of learning from Mr. Ellis, and for acknowledging the limits of one person's capabilities to fix a problem. The bulk of the content, though, is limited to the data and observations, whereas most from the colonies provide more stories in addition to tables of data.

Another stark contrast in the American work is that of images. Four images taken from the major publications further show the concerted efforts on the part of American observers to document their experiences, here using visuals in addition to narratives and lists. In Figure 2[18] and Figure 3[19] from Norriton and Philadelphia, we see detailed drawings of both the sun and Venus alongside multiple data points, whereas in the two drawings from Britain (Figure 4[20] and

[17] William Wales and Joseph Dymond, "LXV. Astronomical Observations Made by Order of the Royal Society, at Prince of Wales's Fort, on the North-West Coast of Hudson's Bay. By William Wales and Joseph Dymond," *Philosophical Transactions of the Royal Society of London* 59 (January 1997): 483, https://doi.org/10.1098/rstl.1769.0065.

[18] John Ewing, "An Account of the Transit of Venus over the Sun, June 3d, 1769, and of the Transit of Mercury Nov. 9th, Both as Observed in the State-House Square, Philadelphia. By the Committee Appointed for Those Observations. Drawn up, and Communicated, in Behalf of the Committee, by Rev. John Ewing, A. M.," *Transactions of the American Philosophical Society* 1 (1769): 42–88, https://doi.org/10.2307/1005004.

[19] Smith, "Account of the Transit of Venus Over the Sun's Disk, as Observed at Norriton, in the County of Philadelphia, and Province of Pennsylvania, June 3, 1769. By William Smith, D. D. Provost of the College of Philadelphia; John Lukens, Esquire, Surveyor-General of Pennsylvania; David Rittenhouse, A. M. of Norriton; And John Sellers, Esquire, One of the Representatives in Assembly for Chester County; The Committee Appointed for ... Author(s): William Smith, John Lukens, David Rittenhouse, John Sellers, Doctor Smith and Nevil Maskeline Source: , Vol. 59 (1769), Pp. 289-326 Published by: Royal Society."

[20] Null Bayley, "XXXVI. Astronomical Observations Made at the North Cape, for the Royal Society," *Philosophical Transactions of the Royal Society*

Figure 5[21]), we see hasty sketches. Although it is possible other British and European observers drew charts for publications not examined for this research, the point is that the American efforts funded by the APS illustrate strong enlightenment ideals of precision craft and attention to detail, of a desire to prove to the world that Americans could do this serious work, and do it with aplomb.

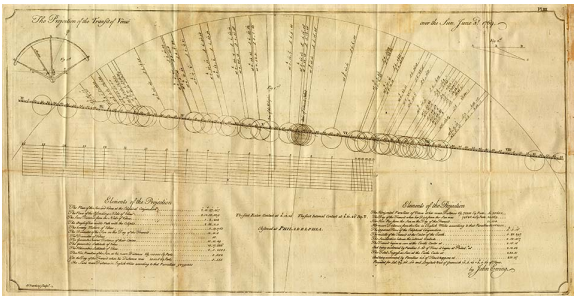


Figure 2.
A detailed drawing by John Ewing from the Philadelphia observation.

The last aspect we examine is the technology, and here the Americans again surpass in detail. Telescopes and clocks were the high-tech tools for understanding how the planets worked. Because the accuracy of the data relied on the craft of the technology in addition to its skilled use, nearly every American account specifically lists the type, design, and manufacturer of the telescopes used. In contrast, many of the British and French accounts are more general. For example, one of France's most important astronomers and mathematicians, LaLande, documented using an "achromatic telescope at Paris of 12 feet focus, made by M. Antheaulme."[22]

of London 59 (January 1997): 262–72, https://doi.org/10.1098/rstl.1769.0036.

[21] James Lind and Nevil Maskelyne, "XLIV. An Account of the Late Transit of Venus, Observed at Hawkhill, near Edinburgh. In a Letter to the Astronomer Royal, from James Lind, M.D. at Edinburgh. To Which Are Added Some Remarks by the Astronomer Royal; and Further Particulars Relative to the Observations Communicated in Other Letters," *Philosophical Transactions of the Royal Society of London* 59 (January 1997): 339–46, https://doi.org/10.1098/rstl.1769.0044.

[22] Joseph Jerome Le Francois De Lalande, Nevil Maskelyne, and M. Messier, "L. Observations of the Transit of Venus on June 3, 1769, and the Eclipse of the Sun on the Following Day, Made at Paris, and Other Places. Extracted from Letters Addressed from M. De La Lande, of the

Jeremiah Dixon's journal of observations, however, mentions only "instruments,"[23] although perhaps he relied on his partner Bayley to list their equipment, but Bayley's account also only lists "instruments," and Bayley spends far more time describing how he fastened and set the clock:

> Set up an oak plank 4 3/4 inches thick, and 14 inches wide. This plank was set a little more than 2 feet in the ground, and well rammed with earth and stones so that it was very steady and firm; to which I screwed the agronomical clock truly perpendicular (by which means it was independant [sic] of the observatory and its shaking by the wind) and set it going nearly with sidereal time.

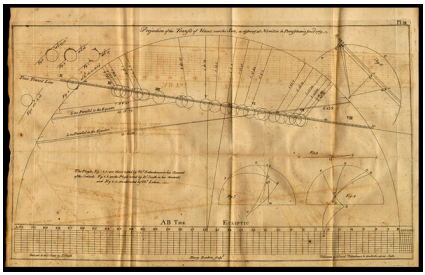


Figure 3.
One of several drawings by David Rittenhouse from Norriton.

These 1769 descriptions mirror those of Abbé Chappe d'Auteroche, who wrote in 1762 that his observatory was made of large wood planks, very solid, with brick paving around. He had a 10-foot telescope with a micrometer and two eyepieces for viewing the entire sun while also seeing close up.[24] These documents,

Royal Academy of Sciences at Paris, and F. R. S. to the Astronomer Royal; and from a Letter Addressed from M. Messier to Mr. Magalhaens," *Philosophical Transactions of the Royal Society of London* 59 (January 1997): 374–77, https://doi.org/10.1098/rstl.1769.0050.

[23] "Observations Made on the Island of Hammerfost, for the Royal Society. By Jeremiah Dixon," 253.

[24] Abbé Chappe d'Auteroche, *Memoire du passage de Venus sur le soleil : contenant aussi quelques autres observations sur l'astronomie, et la declinaison de la boussole, faites à Tobolsk en Siberie l'année 1761 : lû à l'Academie impériale de St. Petersbourg le 8 janvier 1762* (A St. Petersbourg : De l'Imprimerie de l'Academie impériale des science, 1762).

although nowhere near an exhaustive search, provide a representative sample of both French and British observations, foreign and domestic, that were general in nature.

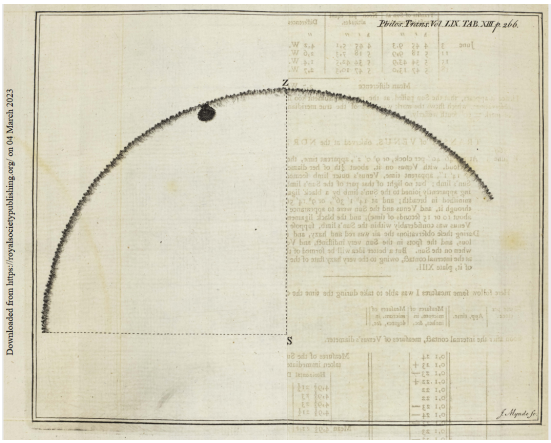


Figure 4.
A drawing included in Bayley and Dixon's article, showing a lack of detail compared with the two American figures.

The Americans, on the other hand, were far more detailed, and this attention to detail demonstrates an honor to enlightenment ideals of precision and care. The Norriton team, for example, gave precise descriptions of type, design, manufacturer, and even ownership:

> 1. A 24 feet Gregorian reflector, with a Dollond's micrometer, made by Nairne, its/magnifying powers 55,95, 135, and 200 times. The gift of the honourable Thomas Penn, Esquire, to the College of Philadelphia. Used by Doctor Smith. 2. A refractor of 42 feet, its magnifying power about 140. The glasses sent to the Assembly, with the large reflector, from England. Used by Mr. Lukens.[25]

[25] Smith, "Account of the Transit of Venus Over the Sun's Disk, as Observed at Norriton, in the County of Philadelphia, and Province of Pennsylvania, June 3, 1769. By William Smith, D. D. Provost of the College of Philadelphia; John Lukens, Esquire, Surveyor-General of Pennsylvania; David Rittenhouse, A. M. of Norriton; And John Sellers, Esquire, One of the Representatives in Assembly for Chester County; The

And with telescopes, David Rittenhouse was in a category alone, especially given that the colonies did not have access to the same materials and manufacturing that Europe provided, for Rittenhouse the expert horologist designed and built his own telescope having "an object glass of 36 feet focus, and a convex eye glass of 3 inches, magnifying about 144 times."[26] To accompany the first telescope built in America,[27] Rittenhouse also constructed a solid observatory with clockwork-like mechanisms for moving the telescope smoothly as it follows the sky. These types of gearing systems are still in use today, but at the time, Rittenhouse's craft was beyond anything others had.

Figure 5.
James Lind in Scotland sketched this for his observation.

Two more examples illustrate the care and attention to documenting the American efforts. First, Owen Biddle and Joel Bayley, at Lewestown, PA, wrote detailed descriptions of setting a post, fixing the clock, and measuring their latitude based on the Mason-Dixon line. They also had more detail to their telescope description:

> The telescope I made use of for viewing the transit, was a reflecting one, belonging to the Philadelphia Library Company, the speculums of which are 2½ feet apart, and the lenses in the

Committee Appointed for ... Author(s): William Smith, John Lukens, David Rittenhouse, John Sellers, Doctor Smith and Nevil Maskeline Source: , Vol. 59 (1769), pp. 289-326 Published by: Royal Society," 296.

[26] Smith, 296.

[27] S.A. Mitchell, "Astronomy During the Early Years of the American Philosophical Society," *Science* 95, no. 2472 (May 15, 1942): 489–95, https://doi.org/10.1126/science.95.2472.508.

> eye tube four inches apart; it was the least magnifying power that I used, as I found the tremulous motion too much magnified by the other power. The small one was in good order, and defined the Sun's limb, and spots on its disc, very clearly. I had applied a polar axis to it, and made some rack-work, by which I could keep the same part of the Sun's limb in the field with ease; my companion was not so well provided with a telescope, the one he used being of Dollond's refracting glasses of 4½ feet. This we fixed, with a ball and socket, to a post, by which it was easily directed to the Sun.[28]

And second, John Ewing's group in Pennsylvania, the main group assigned by Franklin's APS, writes not just of the type and size but also who lent those telescopes to the effort:

> Our Telescopes were, a large Reflector of 4 feet focus and 7 inches aperture, which magnified from 100 to 400 times with an excellent Micrometer of Mr. Dollond's construction fitted to it, which the Assembly of the province had ordered over at the request of the Society; a Refracting Telescope of 24 feet focus belonging to Miss Norris; two Reflecting Telescopes of 18 inches focus, one the property of Mr. Hamilton, the late Governor of this province, and the other of Mr. Prior, together with another Reflector of 12 inches focus.

Documenting far more details than most of the well-funded and well-known astronomers is one major piece of evidence that the American colonists understood the seriousness of their endeavors, the importance of not only recording their history but also recording for the global scientific community.

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[28] Biddle, Bailey, and Thomas, "An Account of the Transit of Venus over the Sun, June 3d, 1769, as Observed near Cape Henlopen, on Delaware. By the Committee Appointed for That Observation. Drawn up and Communicated, in Behalf of the Committee, by Mr. Owen Biddle."

Their efforts were so well performed that in a letter to Thomas Penn, renowned British astronomer Nevil Maskelyne wrote that the American observations were "excellent and compleat[sic]" and "do Honor to the Gentlemen who made them."[29] These rational human efforts contributed empirical data collected through reason and science.

David Rittenhouse: American Genius

Dr. Benjamin Rush said of David Rittenhouse, "without literary friends or society, and with but three books, he became, before he had reached his twenty-fourth year, the rival of two of the greatest mathematicians of Europe."[30] Rittenhouse was an autodidact whose skill was tapped by George Washington, who appointed Rittenhouse to Director of the US Mint,[31] a job mirroring that bestowed on Isaac Newton. Rittenhouse was a genius on many levels, but his calculations of the parallax, done in collaboration with William Smith, should be acknowledged as a monumental accomplishment of the human intellect.

A recent biographical article on Rittenhouse remarked on the accuracy of his calculations of parallax, stating that "[w]ith data collected from stations across the world, Rittenhouse calculated [the parallax] as 8.805 seconds. … Modern methods, by comparison, calculate the parallax as 8.803 seconds."[32] This number attributed to Rittenhouse likely comes from a document written shortly after the 1769 transit by Rev. Dr. William Smith. Smith, along with help from Rittenhouse, used their Norriton observations to calculate the parallax, writing that

> with this reduction, therefore, both of latitude and parallax, the calculations for Greenwich and Norriton were repeated, and the Sun's parallax came out, for the external contact 8',805, instead of 8',8715. The difference is so small, that it was

[29] Woolf, *The Transits of Venus: A Study of Eighteenth-Century Science*, 175.

[30] "RITTENHOUSE: Sketch of the Distinguished Germantown Philosopher" (The Philadelphia Inquirer, May 12, 1882).

[31] Palmieri, "American Philosophical Society."

[32] "Stories of Penn Scientists: David Rittenhouse," Penn Today, May 31, 2019, https://penntoday.upenn.edu/news/stories-penn-scientists-david-rittenhouse.

> not thought worthwhile to repeat anymore of the calculations on that account; especially as the final determination of the Sun's parallax, from the late transit, as was hinted already, will not be left to depend on our calculations in America.[33]

The "reduction" mentioned here is a detail critical to making precise calculations and one that we don't find in other published calculations:

> There is one small nicety, which the extreme strictness of the modern Astronomy might have required to be taken into the foregoing calculations; and which was not thought of in time. In the hypothesis of the Earths being an oblate spheroid, the true latitude of places is more south than the apparent latitude…[34]

What Smith notes here is that rather than being a perfect sphere, the Earth bulges at the equator and thus is slightly fatter at the equator than taller as measured from pole to pole. This slight flattening does impact precision; however, what is nearly as significant is the last remark, that the parallax "will not be left to depend on our calculations in America." Given that their calculations were stunningly accurate for the time, it is a shame that those in London were not more open to the offerings from an enlightened America.

What isn't clear from Smith's document, though, is exactly how much of the work was in collaboration with Rittenhouse. Further, we can criticize the biography for cherry-picking this most-accurate value because Smith's document walks the reader through dozens of calculations given different assumptions. Having said that, Rittenhouse clearly contributed tremendous skills to the work, and his collaborations, particularly with Smith,

[33] William Smith, "The Sun's Parallax Deduced from a Comparison of the Norriton Observations of the Transit of Venus, 1769; With the Greenwich and Other European Observations of the Same," *Transactions of the American Philosophical Society* 1 (1769): 70, https://doi.org/10.2307/1005019.

[34] Smith, 69.

firmly placed the colonies on the international map as a place where advanced science and mathematics were rising.

The Transit as Enlightenment Exemplar

If the American Enlightenment is characterized by a commitment to the ideals of liberty, progress, and the pursuit of knowledge, the events in the American Colonies of the 1769 transit make the perfect scientific exemplar. The colonists demonstrated liberty by self-organizing, taking charge of observations, and not letting England's neglect affect their plans. They studied the science, procured the telescopes, and meticulously noted their observations, all in the hopes that their contributions would meaningfully impact the progress of science the world over. Average citizens gathered during the transit to watch the astronomers work, and some even wrote brief letters of their personal efforts in recording the transit (see, for example, John Leeds[35]).

Although the events at Norriton were examined here, more evidence of enlightened thinking and further examples in support of an American Enlightenment could be found by deeper analysis of the major observation efforts, in particular those in Philadelphia, Delaware, Massachusetts, and Providence, Rhode Island. The combined efforts of members of the American Philosophical Society expanded human knowledge and gave the new United States an intellectual foundation upon which citizens could build and grow some of the most important universities and scientific labs that exist today. Their work sought answers to the big scientific questions, and their rational approach to observing the transit serves as a most excellent example of enlightenment attitudes.

[35] John Leeds, "Observation of the Transit of Venus, on June 3, 1769. In a Letter from John Leeds, Esquire, Surveyor General of the Province of Maryland, to John Bevis, M. D. F. R. S.," *Philosophical Transactions (1683-1775)* 59, no. 1769 (December 21, 1769): 444–45.