Opinion Page

Opinion Page: Franklin and the kite: What can we learn from this episode? *Breno Arsioli Moura*

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In January of 2020, to commemorate the "International Kite Day" (14th January), the Royal Society published in its official account on Instagram a post with an engraving from the 1860s showing Benjamin Franklin (1706-1790) flying a kite amidst a storm with the following paragraph:

> Benjamin Franklin's most famous contribution to science is the Philadelphia kite experiment. In the 1750s, the nature of electricity was not yet clearly understood & harnessing its power was a scientific ambition rather than reality. His experiment showed the connection between electricity and lightning. #InternationalKiteDay

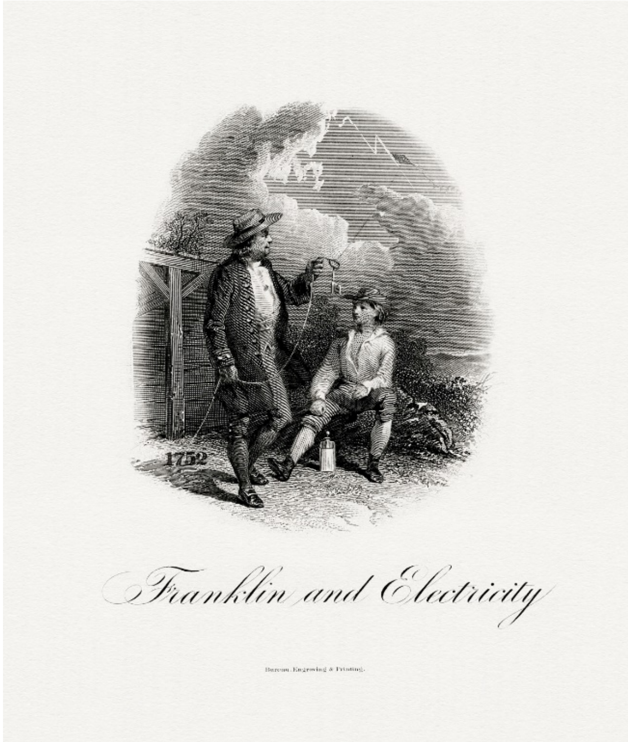

Figure 1 – Engraving showing Franklin performing his kite experiment in Royal Society's post on Instagram.

I have been working with Franklin's studies on electricity for some years. Recently, I have published the book, *A Filosofia Natural de Benjamin Franklin: traduções de cartas e ensaios sobre a eletricidade e a luz* [*Benjamin Franklin's Natural Philosophy: translations of letters and essays on electricity and light*] (EdUFABC, São Bernardo do Campo, 2019), with – as the title indicates – translations to Portuguese of some of his writings on electricity and light, along with commentary. The research took around five years and I cannot say enough how much I have learned about electricity and optics in the eighteenth century – the latter, my main field of study – and about Franklin himself. He is without a doubt an interesting and relevant figure of history of science. Therefore, when I read the publication of the Royal Society on Instagram, a mixture of happiness and sadness reached me. Happiness because is always good to see a name such as Franklin being remembered, studied and discussed. Sadness, on the other hand, because his kite experiment continues to emerge as his greatest, if not only, contribution to the history of science.

The historiography on Franklin shows a multiplicity of contributions that goes far beyond the kite experiment. It is true that Franklin never played a central role in the modern historiography of science, in a way such as Galileo Galilei (1564-1642), Isaac Newton (1642-1727) or Albert Einstein (1879-1955). There is not a "Franklin industry" in historiography as we have for Newton, for instance. This may be a controversial opinion, but I could not identify a long-term historiography on his life and works, even though he is the subject of many books and papers. Notwithstanding, the studies of Franklin portray a more complex figure, not only the ingenious man that one happy day decided to fly a kite during a severe storm.

Firstly, Franklin did not publish a treatise on electricity, as many may think, nor did he publish a report on the kite experiment – I will discuss this matter later. We know Franklin's ideas on electricity mainly due to the efforts of Peter Collinson (1694-1768), a British botanist who kept in contact with eminent natural philosophers in the colony in the first half of the eighteenth century. From 1747 to 1751, Franklin and Collinson exchanged letters on electrical matters, following a gift of an "electrical tube" from the latter to the former in order to test some electrical phenomena. In the 1750s, studies on electricity were trending, which led many natural philosophers to investigate its main properties. Stephen Gray (1666-1736) had shown that electricity could be transmitted, Charles Du Fay (1698-1739) had proposed two kinds of electricity – vitreous and resinous – and Jean-Antoine Nollet (1700-1770) wrote on the affluent and effluent flows of electrical fluid, as well as many other contributions from other authors. Therefore, when Franklin began to study electricity, there was not a dark path.

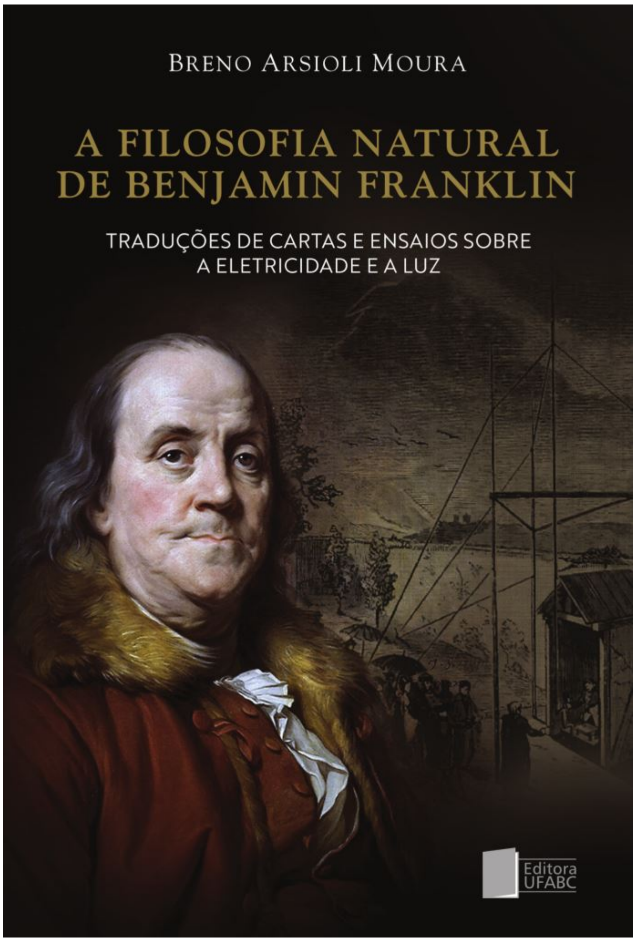

Figure 2 – Cover of my book on Franklin, recently published in Brazil.

Franklin's first letter on electricity was written on March 28 of 1747. It contains only one paragraph, where Franklin acknowledged Collinson for sending him "an electric tube" to perform experiments on electricity. Almost four months later, Franklin sent another letter, with a more detailed description of his endeavours. In this second letter, we can find two of the main concepts of the Franklinian theories for electricity: the power of points and the idea of positive and negative electricity.

He observed that the electrical fire was "drawn off" a charged phial when a sharp object approached. Conversely, if a sharp needle was fixed to the end of a gun-barrel, the latter could not be electrified, since the point of the needle would "throw off" all the electric fluid transmitted to it.

The idea of positive or negative electricity was discussed by an interesting experiment involving two persons standing in separated wax supports and another one standing on the floor. If one of the persons standing on the wax rubbed a glass tube with the other person standing on the wax approaching his knuckle to the tube (without touching the tube or the person), Franklin assumed that the person rubbing the tube lost his/her electricity to the tube, which transferred this electricity to the second person. Therefore, in this configuration, the person who rubbed the tube was electrified "negatively" and the one who collected the electricity from the tube was electrified "positively". Although we do not accept Franklin's ideas nowadays, it is remarkable how his concept still persists, even with the adoption of new conceptions after the nineteenth century.

Other letters from Franklin also revealed more interesting ideas. In an undated letter to John Mitchell (1711-1768), he discussed how thunderstorms were formed. I will give a very short description of Franklin's explanations, but the reader should be advised to consult the original material, in order to see his curious arguments on the nature of matter. According to him, the oceans were constituted essentially by two things: water – a non-electric substance – and salt – an electric substance. The friction in the surface of the ocean made the water electrified. In vaporising, it carried this excess of electricity and very electrified clouds were formed. When these clouds approached mountains or less electrified clouds, the electric fire was transmitted through lightning and then came the rain. This would explain the formation of great rivers, such as the Amazon, near great mountains, such as the Andes. Again, his ideas are outdated, but it is impressive how Franklin managed to combine his conceptions to explain such phenomena.

The most important of his papers and letters was the "Opinions and conjectures concerning the properties and effects of the electrical matter", sent to Collinson on July 29, 1749. In this essay, Franklin resumed his previous concepts – mainly the power of points and the positive and negative electrification – and presented some new and improved ideas. One of them was the model of electrical atmospheres. He believed that, when a body was electrified positively, i.e. a body which contained more electricity than its natural capacity, this excess surrounded it like an atmosphere, with the same shape of the body. Although this was not a new model if we consider Franklin's contemporaries, he seemed to be the first to apply it to electrical phenomena. His other major contribution was the description of the sentry-box experiment. Here we reach a crucial moment in this opinion piece, which deserves a very detailed discussion.

The sentry-box experiment is sometimes associated with the lightning-rod, but they are not the same. Nonetheless, both were cited in the "Opinions and conjectures" – the latter, however, not with this name. Commenting on the power of points to "draw off" electricity, Franklin suggested that "upright rods of iron" should be placed on the top of buildings to prevent the damages caused by the striking of lightning. In this case, the rod was grounded, in order to make electric matter flow from the clouds to the ground. The sentry-box experiment had another purpose.

Figure 3 – The sentry-box experiment, as in Franklin's book.

Franklin's idea was to examine if the electricity of the clouds was the same as those produced in Leiden jars. There was no intention to verify the electricity of lightning, as we may suppose initially. In this experiment, a sentry-box should be built on the top of a tower, with an iron rod of 20 or 30 feet very sharp at the end rising from it. The other end would be connected with a wax support, where a person should stand over. Therefore, the rod was not grounded. According to Franklin, when a cloud approached the rod, the latter would "draw off" the electricity of the former and, if the person approached his/her knuckle, a sparkle could be obtained. Franklin seemed to presume that, in this situation, lightning would not be produced and the person would be safe (the experiment is not safe, by the way).

Two things must be said regarding the lightning rod and the sentry-box experiment. Firstly, Franklin was not the first experimental philosopher to propose an association with the lightning and the electricity produced with Leiden jars or other electrical apparatus. Nollet, for example, had already discussed some similarities between them in 1748. Even Franklin suggested this connection in the letter to Mitchel concerning the formation of thunderstorms and other prior writings. Secondly, Franklin did not perform this experiment when he sent the essay to Collinson. It was, however, reproduced successfully in France, in 1752, one year after Collinson decided to publish Franklin's letters in the form of a book, the *Experiments and observations on electricity, made at Philadelphia*, soon translated into French by the incentive of George-Louis Leclerc (1707-1788), the Comte of Buffon.

The successful reproduction of the sentry-box experiment in France has a close, but not very often alluded to, connection with the kite episode. The French experiment was performed in May 1752. As expected, the news took some time to reach Franklin's ears. In October of the same year, Franklin sent a letter to Collinson – later published in the *Philosophical Transactions* – reporting an experiment similar to the sentry-box, "though made in a different and more easy [sic] manner". This was the kite experiment. However, against all possible commonsense ideas, Franklin did not report how he made the experiments, what were the weather conditions, what he obtained, etc. Instead, he simply gave instructions on how to build the kite, including a special detail: "a very sharp pointed wire" at the top of the upright stick.

This detail is often neglected in the many engravings picturing Franklin's kite experiment. It seems that, for Franklin, the kite experiment was nothing more than a variation of the sentry-box. This is corroborated in his *Autobiography*, where he mentions that the latter was a "capital" experiment, while the kite was only a "similar" way to verify the electricity in thunderstorms.

If the kite experiment was not important to Franklin, how did it become a defining event in the historiography on him? The answer probably relies on Joseph Priestley (1733-1804), a British polymath whose best-known contribution to the history of science was the discovery of oxygen. In 1767, Priestley published his widely famous *The History and Present State Discoveries on Electricity*, a very "Franklinian" book. On commenting on Franklin's contributions to this area of study, Priestley reported the execution of the kite experiment with many details, for example, the presence of one of Franklin's sons. This report – never confirmed elsewhere – was probably the vector to the famous anecdote on the kite. It is not a coincidence that many of the engravings portraying the kite experiment show Franklin with a young man.

A less known aspect of Franklin's works was his opinions on the nature of light. In a letter to Cadwallader Colden on April 23, 1752, he expressed his dissatisfaction with the projectile theory. Franklin claimed that, if light was composed of small particles, then the Sun would vanish sometime in the future. This was a very common argument against the projectile theory in the eighteenth-century. Almost two decades later, Samuel Horsley (1733-1806) responded to Franklin's objections. In two papers published in the *Philosophical Transactions*, he described a series of (feeble) calculations showing that the loss of mass was irrelevant, considering the huge amount of matter of the Sun. Franklin never responded to Horsley. In his letter to Colden, he knew in which scenario he was – a Newtonian one – and he was relieved he was not in times of "philosophical heresy", as Galileo.

Franklin showed some interest in a vibration theory of light. At the end of his life, he wrote again on the subject, in an essay published posthumously by the American Philosophical Society in 1793, but, as before, he did not advance any new ideas. I could mention other areas in which Franklin actively worked, but I feel that the previous discussion in sufficient to evidence that he was involved in many subjects and did not simply fly a kite in the middle of a thunderstorm and discover the electrical nature of lightning.

What can we learn from this discussion? One possible first answer is: in science, there is no "crucial experiment" without a background. Crucial experiments do not emerge unexpectedly and, in most cases, they are not as crucial as we thought they were. Besides Franklin and the kite, I could mention Newton and the apple, Archimedes and the crown, Oersted and the compass, among many others. There is an extensive literature on these historical episodes showing they were not single events without a previous history. Therefore, science does not usually offer magical and instantaneous solutions to problems and doubts. The scientific enterprise develops gradually and is connected with other elements that are not always scientific. In the case of the kite experiment, it was a variation of a more famous experiment – the sentry-box – but its veracity cannot be demonstrated due to the lack of historical evidence.

Secondly, we must not idealise historical scientific figures. By placing Franklin as a sole and brave scientist trying to prove his theory in a risky situation, we are creating a mythical picture of science which is far from reality. If we want to understand Franklin's contribution, we should turn our attention to who he was, what he had experienced before and in which context he was living, to mention just three elements. Franklin was not a scientist or a physicist, in our current standards. He was a natural philosopher, in a broad sense, just as his correspondents and colleagues in the eighteenth century. Franklin was born in one of the colonies of Great Britain. The United States of America did not exist, neither did its scientific power. To the eyes of the British community, Franklin was an outsider, which explains why his first letters to Collinson were not published by the Royal Society. Franklin's experience with typography and the publication of his journals and pamphlets put him in contact with several authors and their books and papers, including natural philosophers. In the eighteenth century, electricity became one of the most studied topics, so many savants were involved with the subject; Franklin was not the only one. Many of his ideas were later developed, altered or rejected, even by himself.

Thirdly, this episode also teaches us about the collective character of science. Although we may be familiar with Franklin's name, he had many colleagues whom he collaborated with, such as Philip Syng (1703-1789), Thomas Hopkinson (1709-1751) and Ebenezer Kinnersley (1711-1778). The latter was particularly known for having advanced the experiments with the kite. In addition, Collinson was essential to making Franklin's works known among the British, otherwise none of his letters would have reached the Royal Society. Buffon also played an important role, since, without his incentive, the translation of his book to French would have taken longer and perhaps the reproduction of the sentry-box experiment may have never occurred in France.

These three suggestions are just a few among many other possibilities that may arise from the history of Franklin's natural philosophy. Getting to know such a fascinating person and such a fascinating time for the history of science can bring many contributions to a better introduction of historical content in science teaching. In these troubled times, we certainly need to improve our comprehension of the many factors involved in the scientific enterprise. Although anecdotes such as this one may at first be amusing, they do not always bring the message we desire for science. The better we understand the history of science, the better we will be prepared for the future that lies ahead.