THE PARALLEL AND ANTIPARALLEL LIVES OF NEWTON AND LEIBNIZ[1]

Alexandru T. BALABAN[2]
balabana@tamug.edu

ABSTRACT:
Main features in the lives of Leibniz and Newton are emphasized, as they appear in a comparative description of their landmark works. Special attention is paid to their controversy about the invention of differential and integral calculus.

KEYWORDS: 17th century, Leibniz, Newton, Leibniz-Newton controversy.

Introduction

The 17th century has a special significance in the history of civilization because it is during this period that what we call the Scientific Revolution began. One can consider that the Renaissance marked only the rediscovery of what the past centuries had accumulated, whereas the first great discoveries in science, and the creation of paradigms that tie at the basis of modern science, belong mainly to the 17th century.

Copernicus (1473÷1543) planted the seeds, but the blossoming of the heliocentric theory due to Kepler (1571÷1630) and Galilei (1564÷1642) occurred during this 17th century. The same century also witnessed the development of the scientific method based on experiment instead of dogmas, or Aristotle's philosophy. The basic principles of the scientific

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[2] Titular member of the Romanian Academy, Professor Emeritus Texas A&M University at Galveston. Links:
http://www.tamug.edu/mars/Faculty%20Biographies/AlexandruTBalaban.htm
https://en.wikipedia.org/wiki/Alexandru_Balaban

method were stated by Francis Bacon (1561÷1626) and René Descartes (1596÷1650).

However, the two greatest personalities of this century are undoubtedly Leibniz and Newton. There are many similarities between these two titans, but also many differences. These two men are also the actors in the most famous scientific controversy about priority in the history of science. The best way to present the similarities and differences appears to be by two tables that will then be discussed in the following paragraphs with the same numbering as in the tables.

Table 1. Similarities

No.	Fact	Leibniz	Newton
1	Lived during	1646÷1716	1642÷1727
2	That is	70 years	85 years
3	Principal achievements at age	20-30 years old	20-28 years old
4	Married	Never	Never
5	Talents	Skilful	Skilful
6	Religion	Deeply religious, rational without bigotry	Deeply religious
7	Sciences practiced	Mathematics, mechanics, optics, astronomy, chemistry	Mathematics, mechanics, optics, astronomy, chemistry
8	Scientific controversies	A few	A few
9	Public service	For 40 years	For 30 years

Comments on Table 1

1-4. Many biographical details are similar between Gottfried Wilhelm Leibniz and Isaac Newton (who was born 4 years before Leibniz, and died 11 years after him, living therefore longer by 15 years).

As professor in Cambridge, Newton had to live in the austere atmosphere of Trinity College and was not allowed to marry, whereas Leibniz chose not to marry.

5. Although Leibniz did not build scientific instruments with his own hands, he was an inventor almost as prolific as Leonardo da Vinci, demonstrating in England and in France (the country where Blaise Pascal also worked on similar ideas) the first machine for numerical computations. This invention led to Leibniz's election as a Fellow of the Royal Society (in 1673) and as a member of the French Academy of Sciences (in 1700). Leibniz was for a few years a member of a society of alchemists, and his chemistry experiments had as aim to improve the preparation of phosphorus, which would be recognized as an element only 150 years later by Lavoisier. Because phosphorus emitted light in air without being heated, it was a very mysterious substance. The procedure discovered earlier by Brand was quite complicated: one had to start with about one cubic meter of urine which had to be concentrated by boiling, leaving a residue that was to be calcined and sublimed for yielding a small amount of phosphorus.

Newton built various scientific instruments himself. By experimenting with lenses and prisms, he discovered that white light could be decomposed into the spectral colors, and reassembled from them. He demonstrated before the Royal Society the colors of ‘thin films and the reflection telescope that was performing much better than the telescopes existing at that time. This latter invention led to his election as a Fellow in 1672, one year before Leibniz. Newton's involvement in alchemical and chemical experiments was much deeper and longer (over 30 years) than Leibniz’s.

However, most of Newton's manuscripts in this field burned in a fire that was apparently caused by Newton's dog which overturned a candle when his master was not at home. Because of this fire, Newton had to write *Optica* again, but his writings on acoustics were lost forever. These losses resulted in a depressive crisis that lasted for about three years. Newton published one paper in chemistry about the nature of acids, but all other chemical writings were destroyed in the fire.

6. Leibniz served reigning houses that were either catholic or protestant. As a consequence, Leibniz who was a religious person attempted to try a reunification of European churches and published several theological papers. In his *Essays on Theodicea About God's Goodness, Man's Free Will, and the Origin of Evil* published in French (Amsterdam, 1710) Leibniz argues that we live in the best of all possible worlds owing to divine grace, that we are duty bound to start with self-improvement and to understand nature better and better. Leibniz believed that science was the best pathway to achieve the moral precepts resulted from Christian philosophy.

Newton knew the Bible as well as Leibniz. Newton's predecessor at Trinity College, Isaac Barrow, was a priest. He made an uncommon move: a few years after being confirmed as professor of mathematics (Henry Lucas had created this chair of mathematics at Trinity College), Barrow accepted to become a chaplain for London's Royal Court. He made Newton his successor when Newton was only 27 years old. Newton was to occupy this function for 30 years. It seems that when Barrow died, Newton did not accept the offer to become a priest and succeed in Barrow's function at the Court. In his religious writings, few of which were published during his lifetime, Newton discussed many religious problems, some of which were connected with the divergence that led to the Reform. For many years, Newton reflected on chronology problems, trying to reconcile biblical writings with archaeological discoveries that were occurring during his lifetime. *The Chronology of Ancient Empires Corrected* was published in 1728, one year after Newton's death. It is fate's irony that this writing was due to attempts by the reigning House of Hanover (which in 1714 was called to rule England) to reconcile Newton with Leibniz. The initial version of this manuscript, for which Newton had worked about 40 years, had appeared in 1725 in French without the author's permission with some errors. Therefore, Newton had to write a corrected version that was published posthumously.

7, 8. Scientific controversies were fashionable in the 16th and 17th centuries because there was no established method for ascertaining priorities in science. There were few scientists and university professors, and these learned about new discoveries mainly from correspondence among them. It was not yet usual to publish fragments from a current research, but one waited till a final work was elaborated, and this was published in book form. For ensuring some priority, one could distribute an anagram whose cipher was to be disclosed when the work was confirmed (this is how Galilei announced some of his discoveries).

The first academies of science appeared only in the 16th and 17th centuries: Accademia del Cimento (Florence, 1657), the Royal Society (London, 1660), Académie Royale des Sciences (Paris, 1666), the Scientific Society (Berlin, 1700), the Russian Academy of Sciences (Sankt Petersburg, 1725). Richelieu had established the French Academy in 1635 as a forum for 40 eminent humanists, and the first humanistic academies had appeared in Italy but had been short-lived. In the period between 1680 and 1690 the first scientific journals had started to be published as proceedings of scientific meetings: *Acta eruditorum* in Leipzig, *Transactions of the Royal Society* in London, *Journal des Savants* in Paris, as well as Italian journals that do not have a bearing with the topic of the present article.

Newton had other controversies on scientific problems: with Hooke on optics, and with Flamsteed on a star catalog. Similarly, Leibniz had also had controversies with Tschirnhaus.

9. The material situation of Leibniz was more precarious than Newton's. The latter led an almost monastic life in Cambridge, but never had to worry about money. Later, as Warden of the Mint (1696÷1699), his income grew, and he gave the royalties for the 2nd and 3rd editions of *Principia Mathematica* to the editor.

By contrast, Leibniz had periods during which he had to interrupt his scientific activity (for instance in Paris in 1676) for accepting jobs with reigning courts that allowed him to earn a living, and then to try and resume his ambitious projects. He worked for 30 years on writing the history of the Welf dynasty, bringing this history up to the year 1005.

The scientific controversy between Leibniz and Newton

Probably no other conflict in the history of science has been so much commented as the famous controversy between Newton and Leibniz concerning the *infinitesimal calculus* that was called by Newton *fluxional calculus*, and by Leibniz *differential calculus*.

The basic ideas were the same, only terminology and notation differed. Nowadays we use mainly the terms and notation proposed by Leibniz. It is almost certain that Leibniz had seen in London in 1676 Newton's first manuscripts, and in 1677 there were several letters exchanged between them. However the ulterior development took place simultaneously and independently. The first edition of Newton‘s *Principia* (*Philosophiae Naturalis Principia Mathematica*) was out of print in 1691. In that edition he had written ten years earlier he had exchanged correspondence with Leibniz, mentioning that “this celebrated scientist replied that he had found a similar method which differs only little from mine, namely in terminology and the representation of formulae”. It is probable that Newton delayed for so long the publication of his mathematical results because he had been totally absorbed by his optical experiments. However, even the publication of his book on optics had to wait for a long time (three editions in English in 1704, 1717, and 1721, as well as one in Latin in 1706).

Leibniz published his results in *Acta Eruditorum*: the studies on differential calculus in 1684 and those on integral calculus in 1686, closing thus his mathematical studies. Unfortunately, Newton's name is not mentioned at all in the first publication, and only marginally in the second one.

Between 1690 and 1700, the new mathematical analysis in Leibniz's formulation was intensely applied in France by the Bernoulli brothers (Jacob and Johann) and by the Marquis de l'Hôpital. In 1693, Leibniz wrote to Newton who replied that “friends are dearer to me than mathematical discoveries".

This was the peaceful situation until the latent conflict was kindled by national pride and by vested interests of third parties. The English circles asked Newton to assert his priority, but he continued to keep silent. The Swiss born mathematician Fatio de Duillier had been a close friend of Leibniz, but they had quarreled. As revenge, Fatio published in 1699 a pamphlet in which he claimed that Newton had priority and alluded to plagiarism by Leibniz. The controversy aggravated when Newton's *Optics* (only in the 1704 edition) appeared with two chapters describing infinitesimal calculus, with an explanatory note in the preface stating that these chapters contained details that had not been described in the *Principia*. An anonymous book review for the *Optics* book in *Acta Eruditorum* (a journal close to Leibniz) accused Newton of plagiarism. In 1708, John Keill published in England a rebuttal accusing directly Leibniz of plagiarism.

In 1712 the Royal Society appointed a commission to investigate this controversy, and this commission that included Halley, a close ally of Newton, concluded in his favor. Even Leibniz's death in 1716 did not end this controversy: ulterior editions of *Principia* no longer acknowledged Leibniz's merits. Nowadays one inclines to believe that the ideas have developed independently, despite the fact that Newton's discoveries precede by several years those of Leibniz.

A sad consequence of this controversy was the fact that Leibniz's notation, which allows easier generalizations, failed to be introduced in England for more than a century, thus delaying the development of mathematical analysis in Britain.

Table 2. Differences

No.	Fact	Leibniz	Newton
1	Born in	Leipzig, Saxony	Grantham, England
2	Lived in countries	Germany, France, Holland	England
3	Longest residence in city	Wolfenbüttel, Saxony	London, England
4	Studies	Doctorate in law	Mathematics
5	Jobs	Librarian, then law counselor and historian of the Braunschweig-Lüneburg ruling house	Professor at Cambridge then Warden (later Master) of the Mint University
6	Travels	France, England, Holland, Austria, various German Lands	Never outside England
7	Languages spoken	German, French, English, Latin, Greek	English, Latin, Greek
8	Philosophy	Hypothesis about monads	"*Hypotheses non fingo*"; corpuscular theory of light
9	Lifetime publications	Few	Very Few
10	Organizer:	Creator and first president of the Brandenburg Academy in Berlin; initiator of the academies of Science in Göttingen, Sankt Petersburg and Vienna (posthumous)	Coin reform
11	Inventor of	Mechanical calculator	Reflection telescope; Newton's rings; light spectrum
12	Honors	Few	Many

Comments on Table 2

1-3. Despite the division of Germany in many countries with different kings and ruling houses, there existed a nascent national spirit uniting these lands that spoke the same language.

4. Leibniz had multilateral interests in addition to his scientific ones, whereas Newton concentrated on science. As a mathematician, Leibniz was self-taught; his encounters with Huyghens and Tschirnhaus were decisive in his mathematical formation. The relationships with the latter went sour after Tschirnhaus published results that Leibniz considered as having been discovered by himself.

Leibniz invented the binary counting system, and as such can be considered as being the precursor of the present-day informatics, mathematical logic, and Boolean algebra. His mechanical calculator proves his attachment for combining science with its applications ("*theoria cum praxi*"). He applied mathematical series and combinatorial analysis to technical, probabilistic and statistical problems.

5-7. Unlike Newton, who never traveled for longer distances than the 200 km that separate the three places where he lived throughout his life (Grantham where he was born in the year when Galilei died, Cambridge, and London), Leibniz's activity covers a much wider geographical area.

Speaking several classical and contemporary languages, Leibniz was able to be with friend many people in France (he had hoped to become a "French-German amphibian") and Holland, and to have an active correspondence with prominent persons in several countries and continents. He tried unsuccessfully to dissuade the "Sun-King" of France, Louis XIV, from invading the Netherlands, by turning his military interests towards Egypt (this advice was later followed by Napoleon). He published in two editions a book about China, hoping to spread Christianity and cultural exchanges in this direction, and using Russia as a bridge towards China. Leibniz also speculated about a universal language long before the invention of Esperanto and other such attempts.

8. Leibniz's philosophy is more comprehensive than Newton's. The latter viewed philosophy as an instrument for knowledge, but for Leibniz science is an instrument of philosophy. The theory of monads, fused with religion (notwithstanding the heresy of this fusion) led Leibniz to postulate various hypotheses. He could accept action at a distance without asking how this could occur; perhaps this attitude prevented him from conceiving the law of universal attraction.

By contrast, Newton had adopted the attitude to refrain from basing his research on hypotheses, to refrain from speculating why and how distant bodies attract each other when he formulated the law of universal gravitational attraction. Even more categorical than his dictum *hypotheses non fingo* from the 2nd edition of *Principia* is his phrase *Ego vero incerta certis miscere nolo* (l do not want to mix certain phenomena with uncertain ones) published in 1671. Nevertheless, Newton did not hesitate to discuss about the all-pervading ether and about light corpuscles.

9. In Annex A one can see a selective bibliography of Leibniz's writings published during his lifetime. He left an immense collection of manuscripts, fortunately well preserved, which is now mostly published or being published by several scientific publishers in Germany.

Newton published even less than Leibniz. Only Darwin, among the other great scientific creators, delayed so long the publication of his results. Probably both these scientific giants had understood the immense responsibility they would have to assume when they would overturn the old paradigms, and had tended to delay as long as possible that moment.

10. We owe to Newton the coin reform, namely the introduction of coins with inscriptions or indentations around the edge. It was thus possible to eliminate the silver coins with lower weight that had been willfully filed off for getting a small amount of silver from every coin. As a reward, he was promoted as Master of the Mint, a better paid job that he maintained during the remainder of his life (1699÷1727).

11. Leibniz had two encounters in Germany with Peter the Great and persuaded him to create the Russian Academy of Sciences in Sankt Petersburg, the capital city Peter had built from scratch. However, Leibniz died before seeing the accomplishment of his wish. He contributed to create the Academy of Sciences in Berlin, but although he was appointed by the Kaiser as its President, he did not lead *de facto* this Academy.

12. As a member of the English Parliament for representing the university during two years (1688÷1699), it seems that the only time Newton spoke was for asking a window to be closed because it causing a draft of air and he was fearing to catch a cold. In 1703, Newton was elected as President of the Royal Society and he was knighted by the Queen of England in 1705. After his death, an official funeral service was held for his entombment in the Westminster Abbey.

Leibniz died in Hannover, and his tomb is there in the Neustadter Kirche. Only the Berlin Academy's secretary, Eckert, participated when

Leibniz's body was deposited. His death was consigned only by a mention from Fontencile, the Perpetual Secretary of the Academy of Sciences in Paris.

Conclusion

Destiny decided that two men so much alike, yet so much different from each other, would intersect their trajectories at the borderline between the 17th and 18th centuries. Only during the following centuries was it possible for mankind to grasp in its plenitude the greatness of these two geniuses, who left an indelible trace in the advance of science, culture, and civilization. Although their findings have been completed by new paradigms, these paradigms were built upon their creations. Despite the corrections brought by the Relativity Theory, Newton's Laws of Mechanics are still valid in everyday life and in space travel. At present scientists strive to detect gravitons and gravitational waves, and they also apply binary calculations in electronic computers.

Nowadays we measure force in Newtons. If cybernetics had been invented in Germany, we would not measure information in bits or bytes, but in units that would immortalize also Leibniz's name.

If a list of names was made for the greatest scientists who ever lived, then Newton, Darwin and Einstein would be included irrespective whether the list would have 5, 10, or more names. However, Leibniz would have to wait for larger numbers, although his human appeal is probably warmer than Newton’s.

Annex A. Works published by Leibniz during lifetime

[1] *Disputatio metaphysica de principio individui*, Leipzig (Colerus) 1663.
[2] *Dissertatio de arte combinatoria*, Leipzig (Fick und Seubold), 1666.
[3] *Nova methodus discendae docendaeque jurisprudentiae*, Frankfurt (Zunner), 1667.
[4] *Specimen demonstrationum politicarum pro elegendo rege Polonorum*, Wilna (Königsberg), 1669.
[5] *Marii Nizolii de veris principiis et vera ratione philosophandi contra pseudophilosophos*, Libri IV, Frankfurt (Sande), 1670.
[6] *Hypothesis physica nova*, Mainz (Küchler), 1671.
[7] *Theoria motus abstracti seu Rationes motuum universales, a sensu et phaenomenis independentes*, Mainz, 1671.
[8] *Caesarini Fürstenerii de Jure suprematus ac legationis principum Germaniae*, 1677.
[9] « Nova methodus pro maximis et minimis », in *Acta eruditorum*, October 1684, pp. 467-473.
[10] « Meditationes de cognitione, veritate et ideis », in *Acta eruditorum*, November 1684, pp. 537-542.
[11] « Brevis demonstratio erroris memorabilis Cartesii », in *Acta eruditorum*, March 1686, pp. 161-163.
[12] « Testamen de motuum caelestium causis », in *Acta eruditorum*, February 1689, pp. 82-96.
[13] *Codex juris gentium diplomaticus*, Hannover (Ammon), 1693.
[14] « Specimen Dynamicum, pro admirandis naturae legibus circa corporum vires et mutuas actiones detegentis, et ad suas causas revocandis », in *Acta eruditorum*, April 1695, pp. 145-157.
[15] « Système nouveau de la nature et de la communication des substances, aussi bien que de l'union qu'il y a entre l'âme et le corps », in *Journal des Sçavans*, 27 June 1695, pp. 294-300 and 4 July 1695, pp. 3-1-306.
[16] *Novissima Sinica historiam nostri temporis illustratura*, 1697; second edition completed 1699.
[17] « De ipsa natura, sive De vi insita, actionibusque creaturarum; pro dynamicis suis confirmandis illustrandisque », in *Acta eruditorum*, September 1698, pp. 427-440.

[18] *Scriptores rerum Bransvicensium*, Parts I-III, Hannover (Förster), 1707-1711.
[19] *Essays de Théodicée sur la bonté de Dieu, la liberté de l'homme et l'origine du mal*, Amsterdam (Troyel), 1710.