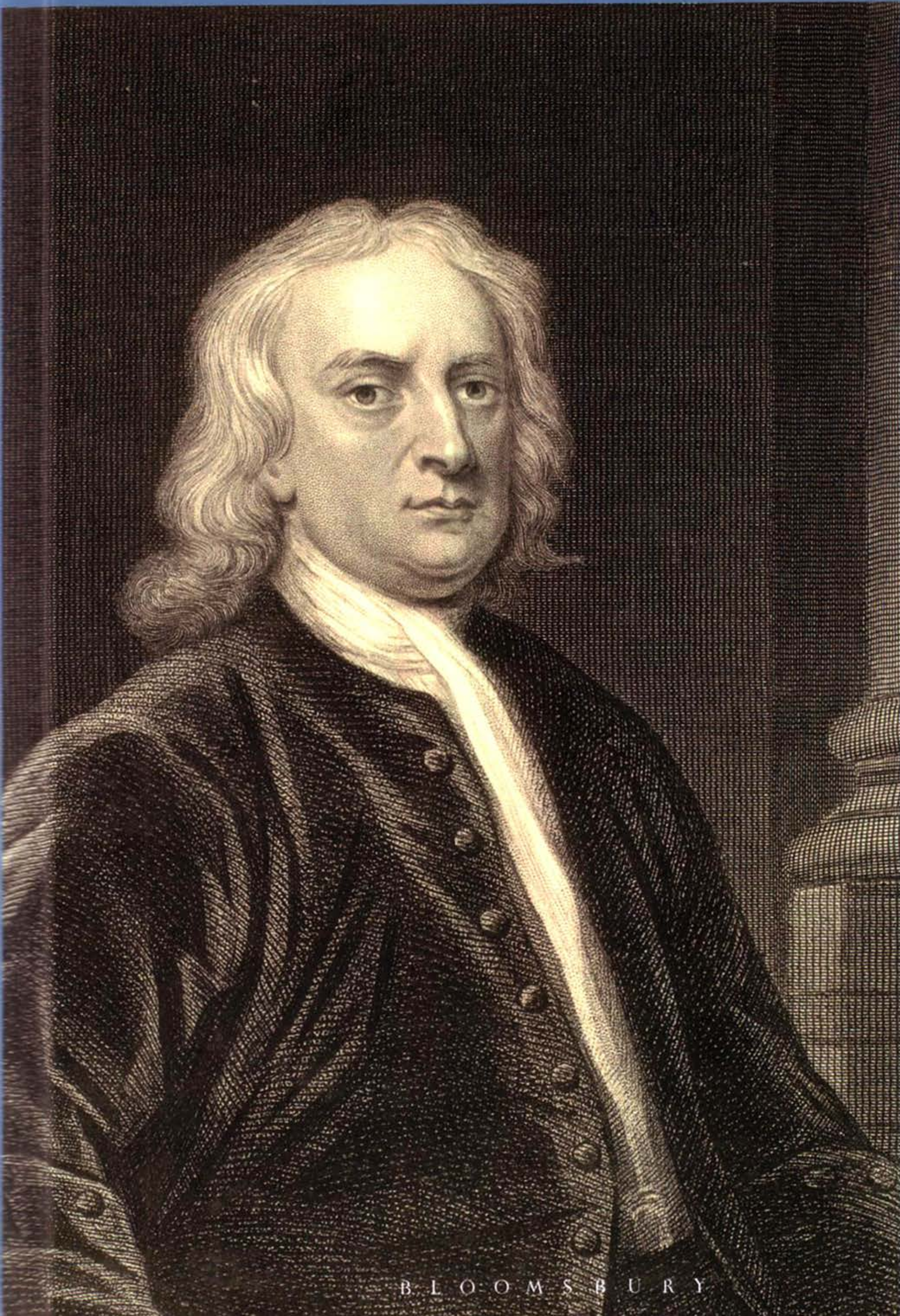
The Reception of Isaac Newton in Europe

Volume I

Edited by Helmut Pulte and Scott Mandelbrote

Series Editor: Elinor Shaffer



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THE RECEPTION OF ISAAC NEWTON IN EUROPE

LANGUAGE COMMUNITIES, REGIONS AND COUNTRIES: THE GEOGRAPHY OF NEWTONIANISM

Edited by Helmut Pulte and Scott Mandelbrote

BLOOMSBURY ACADEMIC
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BLOOMSBURY ACADEMIC
Bloomsbury Publishing Plc
50 Bedford Square, London, WC1B 3DP, UK
1385 Broadway, New York, NY 10018, USA

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First published in Great Britain 2019
Reprinted in 2019

Cover design: Eleanor Rose

A catalogue record for this book is available from the British Library.

A catalog record for this book is available from the Library of Congress.

ISBN: HB: 978-1-3500-9792-6
Set: 978-0-8264-7970-9

Series: The Reception of British and Irish Authors in Europe

Typeset by RefineCatch Limited, Bungay, Suffolk
Printed and bound in Great Britain

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CHAPTER 9
THE RECEPTION OF NEWTONIANISM IN THE GREEK-SPEAKING REGIONS IN THE EIGHTEENTH CENTURY

Kostas Gavroglu and Manolis Patiniotis

The aim of this essay is to describe the ways in which Greek intellectual life during the eighteenth century came into contact with the ideas of the Newtonian natural philosophy. Since most Greek-speaking populations of the time were part of the Ottoman Empire, instead of a geographical reference we are going to use a cultural one. A number of communities dispersed in the Balkans, Asia Minor and central Europe and connected through extended commercial and migration networks comprised the ground upon which the basic traits of an emerging Greek society were shaped. Christian Orthodox religion and Greek-speaking education played a significant role in this process. The former served to identify a particular *millet* within the predominantly Islamic Ottoman Empire and, also, to separate these populations from the Catholics, with whom they came in contact during their travels and migration. The latter offered a common linguistic and cultural reference unifying a great variety of localities, but also promoted the incorporation of many Hellenized inhabitants of the Balkans into the commercial networks dominated at the time by Greek-speaking merchants (Stoianovich 1960; Roudometof 1998).

Intellectual developments, which took place in this context, reflected the fluid and transitory character of such social formations. From the outset of the eighteenth century, a number of social groups sought to assert themselves in the context of a new distribution of power resulting from the decline of the Ottoman Empire. The traditional authority of the Ecumenical Patriarchate over educational, religious and civil matters had been shaken and various local communities attempted to reconfigure their political and economic ties within the broader European space. In what follows, we shall try to examine how the particular type of intellectual activity deriving from such developments interacted with Newtonian ideas and how these ideas contributed to the shaping of certain intellectual trends. To do so, we shall first describe the encounter of the Greek intellectual life with Newtonian ideas by means of the traces this encounter left in the works of the period. Then, we shall present some common historiographical questions and will examine how current historiography tackles them. Finally, we shall try to reformulate these questions in the light of a contextual study of the works presented and to show how such a reformulation may help us to learn more about both the Greek intellectual activity of the time and the history of Newtonianism itself, within the broader European context.

Newtonianism in the Greek Intellectual Context

The introduction of Newtonian ideas into the Greek intellectual space took place basically in the second half of the eighteenth century. During that period, a great number of textbooks were written and published for the use of high school students. Many of them were devoted to such practical issues as arithmetic, geography and 'commercial science'. But a significant number also considered more theoretical and contemplative issues, like metaphysics and natural philosophy. With only a single exception, all these works could be more or less characterized as 'Newtonian'.[1] For the purpose of this research, we reviewed twenty-two such textbooks, especially those which, according to all the evidence, had the greatest impact on the intellectual life of the time. In this section, we shall try to reconstitute the main Newtonian motifs these textbooks employed, in order to establish a certain view of nature. But before doing so, we need to say a few words about the origin and the sources of these works.

Many of the Greek-speaking scholars of the eighteenth century had spent significant time at important European universities. Since the seventeenth century, the dominant tradition was to attend the University of Padua and, to a much lesser extent, other Italian universities. As the decades went by, though, one can observe a shift towards German universities, as well as a turn of the intellectual focus towards German-speaking centres: Vienna, Leipzig and Jena (Patiniotis 2003). In either case, Greek-speaking scholars had the opportunity to be genuine witnesses of various discussions and disputes concerning a number of issues in Newtonian philosophy. They also seem to have been well acquainted with the bibliography and the published sources of the time. This broad perspective concerning Newtonian natural philosophy is clearly reflected in their works. Some of these scholars directly translated renowned treatises which promoted the spread of Newtonian ideas in Europe, such as Benjamin Martin's *Philosophical Grammar* (translated by Anthimos Gazis and published in 1799), Pieter van Musschenbroek's *Elementa physicae conscripta in usus academicos* (translated by Nikiforos Theotokis and published in 1766–1767), Joseph-Jérôme de Lalande's *Astronomie* (translated by Daniel Philippidis and published in 1803) and Francesco Soave's *Istituzioni di logica, metafisica ed etica* (translated by Gregorios Konstantas and published in 1804).[2] Others translated older texts bearing a relevance to the main themes of contemporary natural philosophy, such as Bernard le Bovier de Fontenelle's *Entretiens sur la pluralité des mondes* (1686), whose translator appended a long list of notes turning the originally Cartesian text into a Newtonian confession (translated by Panagiotis Kodrikas and published in 1794). But most of them made compilations. They used a great number of sources, often without

[1] The unique exception is the work of Sergios Makraeos, who wrote one book protesting against the introduction of the heliocentric system (Makraeos 1797) and another (twenty years later) attempting to restore Aristotelian physics (Makraeos 1816). Interestingly, the former employs a certain interpretation of the Newtonian concept of central forces in order to prove the instability of the heliocentric system (see also Vlachakis 1997).

[2] We also know of an unpublished manuscript by Nikolaos Zerzoulis, which displayed a parallel attempt to render Musschenbroek's text accessible to a Greek-speaking audience (Mpenakis 1996).

mentioning them or at least without mentioning the exact origin of the passages they used, in order to select views, findings, proofs and information to build their own natural philosophical accounts. In such cases, Greek-speaking scholars would enter a dialogue with some of the most widespread resources of the trend to Newtonianism: for example, Samuel Clarke's publication of his *Correspondence* with Leibniz (1717) and his famous annotated translation of Jacques Rohault's *Physics* (1697); Willem Jacob 's Gravesande's *Physices elementa mathematica* (1720–1721) and his *Introductio ad philosophiam* (1737); Émilie du Châtelet's *Institutions de physique* (1740); and, of course, Voltaire's *Éléments de la philosophie de Newton* (1738). There is significant evidence that some of the authors might had read Newton's own original texts,[3] but most of them contented themselves with treatises elaborating on various aspects of Newtonian philosophy. In this respect, an important resource for their scholarship was the *Encyclopédie*, which provided them with concise and comprehensive accounts about the latest developments in the field (see Chapter 36 by Maglo in Volume 3).[4]

Turning now to the reception of Newtonian ideas by Greek-speaking scholars, a point of departure is Newton's name itself. The name of 'glorious' or 'unsurpassed' Newton occurs in most of the books we examined (see, for example, Moisiodax 1781, 101, 115; Pamplekis 1786, 167; Kodrikas 1794, 88, 149–52; Koumas 1812, 183; Voulgaris 1838, 33). Its Greek transliteration ('Nephthon' or 'Nephton') is reminiscent of 'Platon', 'Theon' or 'Heron', and served as one of the factors, which placed Newton in a direct connection with ancient Greek philosophy. Greek-speaking scholars for the most part perceived Newton as a prominent representative of the moderns, who had inherited and promoted the pronouncements of classical tradition.[5] His achievements, notwithstanding their novel character, comprised a kind of knowledge relevant to established wisdom about Nature. This point needs to be especially stressed because, quite unlike Newton's, the names of Descartes and Leibniz represented views or opinions, that is ideas in need of substantial revision. This did not, of course, mean that valid knowledge was taken as complete knowledge. The long scholastic tradition showed that even Aristotle's own pronouncements were subject to continuous reinterpretation. But this was because they represented authoritative knowledge. Similarly, the kind of knowledge represented by Newton and his successors was an authoritative knowledge.[6] It invited commentary and

[3] In particular, Newton's *Opticks*. See, for example, Voulgaris 1805c, Part 2, 155; 1805d, 38–41, where the description of the atomic system closely follows Newton's Query 31. The same author, who was one of the most erudite scholars of the time, also cited some important passages from the *Principia*. At 1805d, 98–99, he quoted the laws of motion directly from the first book of the *Principia*, while a few pages earlier (41–42), when discussing the hypothesis of the ether, he cited Newton's views directly from the 'General Scholium'.

[4] Panagiotis Kodrikas clearly stated that in order to turn Fontenelle's text into a Newtonian apology he drew upon the *Encyclopédie* (Kodrikas 1794, title page). This was also the case for another (original) text, which was also written in dialogue form, Rigas' *Florilegium of Physics* (Rigas 1790). See, on this issue, Karamperopoulos 1997; cf. Noutsos 1981.

[5] In a certain sense this was also Newton's own desire (Fara 2002).

[6] Among the names of Newton's followers 's Gravesande's was one of the most cited. His exemplified especially the experimental dimension of Newtonian philosophy.

elaboration, but it was the kind of knowledge needed by philosophy in order to broaden its scope and further its interpretative capacity.

The most important intellectual issue for which Newton's contribution was considered crucial was the cosmological question. Greek intellectual life did not feature the kind of cosmological disputes that occurred in other European contexts. Even the Ecumenical Patriarchate had long ago established a tradition of clear distinction between religious and philosophical affairs (Patiniotis 2004). Thus, although the heliocentric system emerged with some reluctance in the writings of eighteenth-century scholars, it soon came to be taken for granted and to be examined on simply technical grounds.[7] In this respect, although Copernicus was mentioned as the original initiator of this cosmological view, Newton was considered to be the main contributor to the establishment and confirmation of the system.

The discussion on the system of the world took place either in books of physics or in treatises of metaphysics. Most of the latter were at the time divided in three sections, concerning ontology, cosmology and psychology. The middle section was usually devoted to a detailed examination of the world system. It made a comparison of the qualitative features of the three world systems (Ptolemaic, Copernican and Tychonic) and, having established the Copernican system as the true representation of the world's constitution, it continued with a further elaboration of the mechanical issues related to the function and stability of this system. The structure of the few astronomical treatises to appear at this time was similar, whereas books of physics addressed the cosmological issue through the examination of the laws of central forces. The common denominators in all of these cases were as follows:

1. The heliocentric system was taken for granted either because of its immediate plausibility or because of the apparent weaknesses of the Ptolemaic system. The theological objections against the Earth's motion were routinely countered by means of arguments that comprised the standard recourse of most eighteenth-century natural philosophers all around Europe.[8]
2. The heliocentric system became possible thanks to action at a distance, the attractive force identified by the 'celebrated Newton'. In order to establish this tenet, however, it was necessary to deconstruct the Cartesian idea of vortices. Without exception, eighteenth-century Greek-speaking scholars denounced the theory of vortices, as well as any kind of material substance that might be reminiscent of the Cartesian ether. They realized that a world system based on the Cartesian views would not be able either to comply with Kepler's laws or to accommodate the

[7] The first time an indirect mention was made to Earth's motion was in Theotokis' *Elements of Physics*, published in 1766 (Theotokis 1766–1767).

[8] See, for instance, Koumas 1807, 7: 127–31; Moisiodax 1781, 106–23; Rigas 1790, 22–25. Eugenios Voulgaris was a special case in the sense that he subscribed to the Tychonic arrangement of the heavenly bodies because he decisively denied Earth's motion (Voulgaris 1805b). This was, however, his only differentiation, as we shall see below.

'irregular' motion of the comets (Moisiodax 1781, 127–32; Kodrikas 1794, 87–89; Konstantas 1804, 270–71; Voulgaris 1805b, 70–76; Koumas 1807, 7: 272–85). Indeed, so intense was the desire to reject anything Cartesian that one might plausibly think that they adopted Newton because they despised Descartes and not vice versa. One possible reason for this was the potential for atheism that they sensed in the materialist pairing of matter and motion. Apparently they felt much more at ease with Newtonian attraction even though they admitted ignorance concerning its nature.

3. The combination of the universal law of attraction with the centrifugal effect of inertial motion suffices for the explanation of all celestial phenomena. Newton conceived of both the notion of universal attraction and that it functioned according to Kepler's laws. Many books introduced the subject by mathematically proving that the familiar force of gravity, when expanded beyond the limits of the terrestrial globe, may account for the Moon's revolution. By admitting that God endowed all celestial bodies with an initial rectilinear motion and with the property of mutual attraction, Greek-speaking scholars proceeded to generalize this conclusion to the whole universe. The revolutions of so-called 'secondary planets' around 'primary' ones, of all the planets around the Sun, and of all the planets around their respective stars, were results of the same arrangement.[9]
4. Two other important phenomena, which were also adequately explained by the use of Newtonian attraction, were the recurrence of comets and of the tides. Although tides are practically unknown to most eastern Mediterranean shores, the interpretation of this phenomenon was considered a particularly perplexing problem, which had humiliated even the great Galileo. Similar views were held about the irregular motion of the comets, whose Cartesian interpretation by means of crossing vortices endangered the stability of the lunar system. The fact that attraction could provide a consistent explanation for these obscure phenomena that was in accordance with mathematical reason and common experience furthered its reliability as a cosmological principle (Rigas 1790, 61; Kodrikas 1794, 398–400 and 415–24; Philippidis 1803, 2: 343–60; Voulgaris 1838, 33–40).
5. The mathematical sophistication, which characterized the *Principia* and established a tradition that flourished in the hands of Newton's French successors, did not occur in the eighteenth-century Greek scientific treatises. Accounts of the cosmological dimensions of attractive force were to a great extent philosophically inclined descriptions that aimed at establishing the plausibility of the ensuing system. Mathematics was not totally absent, even so. A number of scholars devoted part of their books in the treatment of 'central forces'. 'Centrifugal' and 'centripetal'

[9] Voulgaris, for example, notwithstanding his denial of Earth's motion, employs this scheme to account for the causes of the star's motions (Voulgaris 1805b, 76). See also Darvaris 1812–1813, 1: 47–50; Koumas 1807, 7: 162–73 and 278–85; Konstantas 1804, 291–94; Pamplekis 1786, 153–62; Philippidis 1803, 2: 276–81.

forces account for the production of circular or otherwise curvilinear motions. The most important theorems of the *Principia* were reproduced in Greek texts with varying degrees of faithfulness (there was a certain confusion between inertial motion and 'centrifugal' force), but always in tandem with their expected cosmological application. The kind of motion produced by forces that conform to the inverse square law implied Kepler's laws as they were observed in the motions of celestial bodies. Thus, Newton's attraction won out over the qualitatively obscure Cartesian theory of vortices, and it also conformed to the precise mathematical calculations, which might be derived from the systematic observation of the celestial phenomena.[10]

6. Notwithstanding their Aristotelian background, eighteenth-century Greek-speaking scholars displayed an impressively pragmatic view concerning the causes of attraction. They unanimously agreed with Newton that we are ignorant of the true causes of this force, but that, since it can adequately explain not only the constitution of the universe, but also the Earth's shape,[11] we should take it as a real property of matter, like impenetrability, movability or extension. Indeed, Greek-speaking scholars tried to distance themselves from the quasi-atheistic Cartesian perception of the re-distribution of motion through successive collisions among inert material particles. Some clearly declared (and others implied) that the origin of every motion should lie with God. Thus, a scheme which employed a notion of matter endowed by God with attractive force, along with an initial impulse exerted by him on celestial bodies, and in which the combination of these two factors resulted in the observed curvilinear trajectories in the heavens, was much more in accordance with their religious commitments (Moisiodax 1781, 115–18; Pamplekis 1786, 162–67; Philippidis 1803, 2: 282–85; Voulgaris 1805b, 76).

This, in outline, was Newton's contribution to the establishment of the new worldview in the Greek intellectual life. But eighteenth-century Greek-speaking scholars did not only adopt the cosmological aspect of Newtonian philosophy. Their views about a series of other natural matters were equally affected by Newtonian philosophy. Prominent among these was the question concerning the constitution of natural bodies. Atomism was not a Newtonian innovation. However, the strengthening of the atomist view by means of Newton's contemplations was a significant development in the natural philosophy of this time. Notwithstanding their location in the interrogative context of the 'Queries' at the

[10] For a descriptive reference to central forces, where also the confusion between inertial motion and 'centrifugal' force mostly occurs, see Rigas 1790, 27–29; Konstantas 1804, 294; Koumas 1812, 183; Vardalachos 1812, 654–55; Darvaris 1812–1813, 1: 79–81. For a mathematically sophisticated treatment of central forces, not entirely immune to the above confusion, see Voulgaris 1805d, 163–70; Theotokis 1766–1767, 1: 262–71; Koumas 1807, 5: 3–25; Philippidis 1803, 2: 289–313.

[11] There are quite a few references to the scientific expeditions aiming at the confirmation of the Newtonian prediction concerning the Earth's shape. See, for instance, Moisiodax 1781, 101–05; Pamplekis 1786, 147–52; Philippidis 1803, 2: 142–52; Darvaris 1812–1813, 3: 71–72.

end of the *Opticks*, Newton's ideas about atoms and the forces that made them cohere were a persuasive alternative to the endless divisibility of matter that was assumed by Descartes's followers. Quite a few Greek-speaking scholars cited or indirectly referred to the famous paragraph from Query 31, in which Newton stated his conviction that God had created the ultimate particles of matter so that they would fit into the divine design of Creation (Newton 1952 [1730], 400). From the same query they also took over the discussion about the forces that keep these particles together or, in the light of a number of well-known chemical experiments, might be responsible for the attraction or the repulsion of specific substances. In most cases they stuck to the letter of Newton's text, but they did not hesitate to take some further steps. Thus, when they encountered the discussion about ether as a material agent for dynamical interactions (Queries 23 and 24, Newton 1952 [1730], 353–54) they gently distanced themselves from it.[12] They recognized that this agent might be used to explain those forces that particles exert on each other, whether attractive or repulsive, but, apparently, they were very unsure of the necessity of such a modification to an otherwise clear, dynamical theory. Again, if one looked for an explanatory principle, God might provide it through his ultimate and unmediated agency.[13]

Closely related to the atomic theory of matter was the corpuscular theory of light. Optics was an old and well-established branch of natural knowledge both in Eastern and Western scholarship. Greek-speaking scholars were familiar with the geometrical tradition in optics and this was documented by the presence of chapters devoted to it in the most widespread mathematical treatise of the time (Vasilopoulos 1749, 3: 355–501). It seems, however, that they felt either that they had nothing new to contribute to the discipline or that they did not find any utility in the furthering of geometrical optics. The revival of interest in optics came with Newton and the incorporation of the accounts of his work in books of natural philosophy. Printed sources suggest that all eighteenth-century Greek-speaking scholars subscribed to Newton's speculations on the nature of light rays and the manner by which they stimulate optical impressions. Once again, Descartes (and not Huygens, as was in fact the case in Query 28) was the immediate opponent. Greek-speaking scholars employed a host of arguments from Newton to counter the view that light might be an agitation propagating in a continuous ethereal medium and to show instead that it was the result of the emission of material corpuscles by light-giving substances. They took care nevertheless to explain why the Sun was not and in fact would never be depleted as a result, on the one hand, of the subtle nature of

[12] A unique exception was Veniamin of Lesbos, who seemed to stick very faithfully to Newton's ideas about the ether, as expressed both in the 'Queries' and in the 'General Scholium'. He took these speculations to their ultimate conclusions by rejecting entirely a dynamical view of the universe and substituting for it 'Pantachikiniton' (The All-Mover), an ethereal substance that might account for all the dynamical phenomena of dead and living matter. See Veniamin of Lesbos 1820, 31–46; Dialetis and others 1999, 62–64.

[13] Theotokis 1766, 12–15; Pamplekis 1786, 126–28; Konstantas 1804, 300–05; Voulgaris 1805c, Part 2, 146–58, 1805d, 38–42. For the function of the attractive and repulsive forces, which were responsible for the constitution of material bodies, see Darvaris 1812, 1: 68–81 and Koumas 1812, 13–17. For a Kantian presentation of the same issue, see Koumas 1818–1820, 3: 80–88 and cf. Kant 2004 [1786].

these emissions and, on the other, of the replenishing effect of the attractive force that it itself exerted on the emitted corpuscles. Prominent among the long list of experiments cited from Newton's *Opticks* was the prism experiment, which showed the compound synthesis of sunlight and established the discussion of the nature of light on new ground.[14]

Motion and matter were traditionally the two ingredients of natural philosophy. The importance accorded to each of them defined the specific character of each theoretical tradition. Newtonian mechanics was characterized by the elimination of all metaphysical features from matter and the grounding of motion on forces developed between point masses. One important result of the removal of material agents was that other determinants of kinetic phenomena, like space, time and force, gained significant weight. The new context of rational mechanics, as described in the *Principia*, shaped, over the course of time, a multifaceted discipline in which the metaphysical, empirical and mathematical implications of these issues were thoroughly examined. In the eighteenth-century Greek treatises of natural philosophy, many traces of this discussion may be found. Thus, a number of books have chapters devoted to the investigation of the Newtonian perception of absolute space and time, as well as extended sections clarifying the notion of *vis inertiae* and its relation to motion. The postulation of the three 'laws of motion' was usually the immediate outcome of such investigations and formed the basis for the further elaboration of kinetic phenomena.[15]

One important characteristic of the discussion about the foundations of the Newtonian concept of motion in Greek books of natural philosophy is that with the exception of K. Koumas's highly sophisticated eight-volume *Elementary Series of Mathematical and Physical Treatises* and some parts of the works of Eugenios Voulgaris and Nikiforos Theotokis (Theotokis 1766–1767; Voulgaris 1805d; Koumas 1807), the mathematical dimension of mechanics was largely absent. Most Greek-speaking scholars of the time did not share the desire of many of their European colleagues to establish a mathematical framework for the new physics, devoid of any apparent metaphysical pursuit. On the contrary, they insisted on the clarification of the metaphysical foundations of Newtonian natural philosophy, and thus devoted extended parts of their works to placing the notions of space, time, inertia and motion in the context of a philosophically coherent discourse. At the same time, though, they were aware of the necessity for an empirical grounding of these notions because of the confusion that they might cause to readers who were most familiar with traditional Aristotelian natural

[14] Theotokis 1767, 2–12 (for the corpuscular theory of light) and 134–37 (for the prism experiment); Kodrikas 1794, 148–54; Voulgaris 1805d, Chs 25–29; Koumas 1807, 6: 125–32 (for the corpuscular theory of light) and 183–90 (for the prism experiment); Veniamin of Lesbos 1820, 31–37.

[15] Pamplekis 1786, 187–213 (on space and time); Voulgaris 1805c, Part 2, 99–131 (on space and time) and 178–83 (on *vis inertiae*); Voulgaris 1805d, 73–90 (on space and time) and 69–73 (on *vis inertiae*) and 98–99 (on the laws of motion); Koumas 1807, 4: 234–36 (on space) and 255–60 (on *vis inertiae*; here one may also find a version of the three laws of motion as 'corrolaries' of the 'theorem' which holds that inertia is a universal property of matter); 'Fisiki dimodis' 1810, 56 (on the laws of motion); Darvaris 1812, 1: 27–28 (on space) and 32–40 (on the laws of motion).

philosophy. Therefore, they also devoted part of their discussions to informing their audience about the function of *vis inertiae* and the mechanics based on it, using examples from everyday life and common experience.

Open Questions and Current Historiography

Thus far, we have confined ourselves to a descriptive presentation of specific instances in which Newtonian natural philosophy interacted with eighteenth-century Greek intellectual life. This information alone cannot help us to understand the broader intellectual circumstances that shaped this encounter. Quite a few Greek historians, however, pay almost exclusive attention to the appearance of Newtonian doctrines in the intellectual production of the time, taking them as signs of the changing attitude of Greek-speaking scholars towards modern science. According to such historians, reference to a number of Newtonian tenets or subscription to the mechanical worldview indicated the willingness of those scholars to break with the Aristotelian philosophy and embrace the new natural philosophy. Thus, taking 'Newtonian physics' as a more or less coherent synthesis they did little more than examine how fully and how faithfully it was represented in the works of the time (Kondylis 1988; Vlachakis 1996; Ethniko Idrima Erevnon-Kentro Neoellenikon Erevnon 1997). After a while, such historians came to realize that, notwithstanding the ideologically favourable attitude of many Greek-speaking scholars towards the new natural philosophy, the degree of scientific sophistication of their works remained rather limited.

Experiment is one issue that has puzzled historians concerning the intellectual attitude of eighteenth-century Greek-speaking scholars. In the eighteenth century, Newtonian philosophy was almost synonymous with experimental philosophy and many proponents of the new natural philosophy, like Benjamin Martin, Pieter van Musschenbroek and Willem Jacob 's Gravesande, worked to spread Newton's reputation in this regard. In keeping with this trend, Greek philosophical and scientific books contained a great number of references either to specific experiments or to the value of the experimental study of nature in general. Moreover, through explicit references to Newton's 'rules of philosophizing', they invited their readers to endorse experimental method as the proper way to conduct empirical investigations (Theotokis 1766–1767, 7–10; Voulgaris 1805d, 6; Koumas 1807, 4: 230–31). Beyond the level of verbal endorsement, however, there is no evidence that Greek-speaking scholars in fact conducted any real experiments. They mentioned experiments made by others, they commented on remarkable observations made in European laboratories and observatories, they argued for the acquisition of experimental devices for the use of Greek schools and they declared their adherence to the new empirical method of investigation as opposed to infertile scholastic explanations; but, as far as we know, they do not seem themselves to have systematically conducted experiments (Karas and others 2003, 514–55). At most (and according to scarce evidence) they organized some experimental demonstrations for the enlightenment of their students or maybe of a wider learned public. The heuristic role of experiment and its instrumental use in the quantitative investigation of an external natural world was beyond their scope and it did not appear to be part of the discourse they attempted to construct.

Similar things hold true concerning the mathematization of natural philosophy. Newtonian mechanics (in the beginning, a part of mathematics itself) symbolized the convergence of natural philosophy with mathematics. Since one of Newton's major intentions had been to study the generation of celestial trajectories, mechanics was prompted to cross the border of pure quantification and enter the realm of dynamics. Geometry could not accompany natural philosophy in this venture; the redefinition of space, time and motion went hand in hand with the introduction of calculus as the backbone of rational mechanics over the course of the eighteenth century (Newton 1999 [1687], 382; Patiniotis 2005, 1634–35). This characteristically Newtonian approach was totally absent from eighteenth-century Greek scientific treatises. Greek-speaking scholars were well versed in mathematics and had produced a number of treatises on Euclidean geometry, the conic sections and modern developments in algebra. However, at no point did they link developments in mathematics with those in mechanics, which had in fact fuelled them. To the contrary, their treatment of the fundamental notions of the new natural philosophy retained a high degree of metaphysical sophistication. Several scholars ventured to provide novel syntheses, crossed multiple traditions and employed a highly technical vocabulary, but they persistently avoided involvement with the mathematical technicalities of rational mechanics. The instances of a clear mathematical treatment of dynamics were scarce and even these very soon returned to trivial problems in Archimedean or Galilean mechanics. On the other hand, the emphasis put on informing readers by giving empirical examples drawn from everyday life was significant, and indicated the desire of the authors to handle the new natural philosophy in a primarily qualitative way.

The ambiguous relationship of Greek-speaking scholars with experimental philosophy and mathematics now forms part of a broader historiographical discussion concerning the kind of discourse about natural knowledge developed by these scholars. According to most historians, Greek science lacked originality and creativity. It was a vague reflection of the developments that had taken place in the centres of the Enlightenment, deployed in a Greek context primarily for ideological purposes. However, due to the Ottoman rule over the Greek-speaking populations of the Balkans, even the mere attempt to bring Greek education into contact with Enlightened Europe has been considered a heroic endeavour. For this reason, some historians develop the argument that the apparently low level of philosophical and scientific production and creativity at the time reflected real conditions in this society and that therefore questions of originality are both literally and metaphorically untimely (Psimmenos 1988, 31). Others consider that, although Greek-speaking scholars might not be the kind of natural philosophers who could be met at the time in Western Europe, nevertheless when they decided to convey this new knowledge to their own particular intellectual space, they carried out a process of selection and adapted it for educational use (Karas 1991, 89). The fact that, irrespective of their degree of sophistication, particular scholars assimilated and spread the new scientific spirit in the Greek intellectual space, countering popular ignorance on the one hand and the established authorities on the other was not only important for the revival of Greek intellectual life, but also determined the subsequent political and ideological developments of the region until the Greek war of independence (Henderson 1970, introduction). Indeed, the most characteristic aspect of such historiography is that it persistently links the introduction of the sciences with the enlightenment of the 'nation' in anticipation of national emancipation (Karas and others 2003, 48 (esp. note 9), 49–50, 74).

The problem with this approach is twofold. First, it adopts an anachronistic idealization of Newtonian physics, ignoring its fluid state during the eighteenth century (Patiniotis 2005); second, it obscures the specific historical circumstances under which the contact of Greek intellectual life with Newtonian ideas took place and veils the active participation of Greek-speaking scholars in the formation of a distinctive philosophical discourse about nature. The moral that emerges from the dominant narrative is that since Greek-speaking scholars did not contribute to the shaping of 'original' Newtonian physics, as we perceive it today, they were, at best, conveyors and popularizers of an admittedly successful science, which they themselves were unable to produce. An important question, however, is whether the departure of Greek-speaking scholars from what is now considered a proper scientific attitude was not a result of their ignorance, incapacity or cultural seclusion, but instead a legitimate philosophical choice that indicated the wide range of intellectual attitudes towards Newtonianism at a time of high intellectual and cultural diversification. A careful contextualization of Greek scholars' philosophical endeavours might therefore offer us a clearer view of the philosophical landscape of the time, as well as of the history of Newtonianism itself.

Greek Science in Context

Before attempting such a contextualization, it is necessary briefly to comment on an important issue. The mere fact that Greek scholars directed their scientific and philosophical considerations towards educational purposes did not necessarily bear witness to the low level of their intellectual production, neither did it prove that the only role that they assumed for themselves was one of popularizer of or propagandist for science. The fact that, for the greater part of the eighteenth century, education and intellectual production were still inseparable needs to be taken into account. Notwithstanding the establishment of scientific societies and the spread of experimental philosophy, the practice of modern science remained mostly in the private sphere at this time. Whenever it was practised publicly, it was either for purposes of popularization or for a strictly limited audience of experts. Numerically speaking, the overwhelming majority of professional eighteenth-century philosophers were university professors, many or even most of whom taught philosophy according to inherited scholastic models (Lüthy 2000, 171–72). These models implied that the acquisition of knowledge should be pursued by means of literary devices contrived and applied in front of one's students or written and diligently analysed for the sake of one's students. The pursuit of knowledge, in other words, was part and parcel of the teaching process and vice versa. Therefore, the only conclusion that may be properly drawn from the educational orientation of the Greek-speaking scholars is that they conformed to the general disposition of their time.

When Andrew Cunningham and Perry Williams published their programmatic paper about the re-orientation of studies of the Scientific Revolution, they aptly noted that:

> It is necessary to identify the particular and specific 'projects of enquiry' in which people in the past were engaged in their investigations of nature. [...] When we read texts from the past, we need to ask ourselves, 'to what *question* – both what immediate question, and what project of enquiry – in the life and world of the person who wrote it, was this text the *answer* for its author?' For without knowing the project that a particular historical actor was engaged on, the results arrived at by that historical actor are meaningless to us; the answer is meaningless without the question. [...] [This principle] suggests that we should direct our attention, not simply to statements about the natural world in past texts, but to the precise enterprise of which these thoughts and statements were part and which gave them their identity and meaning.
>
> *Cunningham and Williams 1993, 420*

This is exactly what most Greek historians have failed to do. The kind of questions that they have asked result from the tendency of many historians of science to explain away the departures from, or the distortions of, a scientific theory, which later came to prevail in scholarly life, whereas they do not feel any urge to investigate the particular conditions that enabled the establishment of a theory, as a result of the fact that they regard its 'truth' as an adequate condition for its success.

This causes significant problems in cases where the replacement of one intellectual context by another may be far from self-evident. One such case is the continuity of Aristotelian tradition, which formed an important constituent of eighteenth-century Greek scholarship. As Edward Grant has noted, Aristotelian tradition was never a dead body of commentaries, insensitive to the new trends of philosophy. It comprised a wide range of philosophical undertakings in the Middle Ages, capable of surviving in various environments and, in the early modern period, it established a comprehensive dialogue with the new natural philosophy, resulting in the assimilation of specific aspects of this philosophy within an Aristotelian framework (Grant 1987; Mercer 1993). If one accepts this perspective, the examination of Newton's emergence in a Greek intellectual context may lead to some interesting questions, which go beyond the beaten track of current historiography. Instead of striving to explain why eighteenth-century Greek-speaking scholars were unable to assimilate properly the Newtonian natural philosophy, one might ask why should they appreciate Newtonian ideas and favour their introduction into their familiar intellectual context? Why should they subscribe to a drastic change in a worldview that continued to function seamlessly in their own environment? Why did they admire Newton and why were they motivated by his achievements? Finally, what kind of cognitive enterprise did their dialogue with Newtonian natural philosophy serve and what was the intended outcome of such an enterprise?

In order to outline a proper context for dealing with such questions, one should take into account the cultural dispositions of the actors. Starting from their acquaintance with the anti-scholastic Alexandrism of Padua, which emphasized inquiry into natural causes and even placed physics above metaphysics, Greek-speaking scholars were well prepared to participate in discussions about new ways of investigating nature.[16] The close ties of this trend with Renaissance naturalism and the empirical background of the treatises that resulted from this intersection helped Greek-speaking scholars become familiar with the inductive method of contemporary science and appreciate its findings. At the same time, it remains a fact that Greek-speaking scholars never ventured into empirical investigations themselves. What they valued as knowledge proper, and at which their intellectual activity aimed, was a well-organized and hierarchical set of principles that would allow them to reduce all the observed phenomena to a deeper layer of natural causes.[17] They did not reject the notion of natural law, which could be reached through experimental investigation, but they were convinced that it sufficed only for the description of the appearances. To take up the familiar Aristotelian terminology, real physics was only 'justified physiology' as opposed to 'historical physiology' (Voulgaris 1805d, 2–5) – causal accounts as opposed to mere quantitative or qualitative correlations.

The mathematization of natural philosophy was also an ambiguous issue for Greek-speaking scholars, although not only for them. Historians used to take the algebraization of natural philosophy as a general trend, but there were indeed people all around eighteenth-century Europe who distrusted mathematics. Diderot's aversion to it is well known, but more relevant to our discussion was the idea, widespread in mid-eighteenth-century Germany, that mathematics was inappropriate for the study of natural truths. Greek-speaking scholars were much affected by the German Enlightenment and Christian Wolff's views were dear to many of them.[18] Wolff and his followers were among those who objected to the use of mathematical principles in the study of Nature, due to the fact that although

> mathematics might be useful to describe certain phenomena, it did not explain them, because the causes of phenomena such as gravitation were not mathematical.

[16] The founder of this tradition in Greek intellectual life was Theophilos Korydaleus 1563/74–1646. On Korydaleus's life and work, see Tsourkas 1967; on Paduan Alexandrism, see especially Tsourkas 1967, 179–95. For the intellectual atmosphere in sixteenth-century Padua, see also Schmitt 1980, 1983.

[17] For a concise overview of relevant case studies, see Karas and others 2003, 63–66, although the historiographical interpretation pursued here is significantly different from the one pursued by that volume's authors.

[18] For the scientific travels of Greek-speaking scholars to the German-speaking countries of Central Europe, see Patiniotis 2003. Most of the books cited as original sources by this paper were published in Vienna, which is also indicative of their authors' relationships with the German-speaking world. On this issue, see Patiniotis 2006. On the real presence of Christian Wolff and other German authors in eighteenth-century Greek intellectual production, see Karas 1992–1994. For the social and intellectual interaction of Greek-speaking scholars with the German Enlightenment see, as an example, Eugenios Voulgaris's biography in the digital library *Hellinomnimon* (http://dlab.phs.uoa.gr/), edited by M. Patiniotis and B. Spyropoulou.

> The fact that a particular mathematical formula could be used to predict the speed of a falling object did not mean that the object fell because of this mathematical regularity. For the sake of mathematical understanding much can be invented, but these mathematical fictions are not themselves the true causes, by which the effects of Nature are explained in an intelligible fashion.
>
> *Ahnert 2004, 481*

Greek-speaking scholars clearly found this intellectual attitude sympathetic. They confined themselves to the descriptive use of mathematical formulae to depict the workings of Nature, but carefully refrained from assigning to such formulae a deeper ontological status. In accordance with a number of contemporary philosophers, they believed that examination of the deeper ontological status of natural truths invited the use of more sophisticated philosophical devices than 'mathematical fictions'.

These points can be further clarified if one tries to understand what was the aim of natural investigation in the view of these Greek-speaking scholars. Theophilos Kairis (1784–1853), who was one of the most erudite scholars of the early nineteenth century, ventured to give a definition of scientific knowledge:

> Knowledge is the perspicuous understanding of beings. Partial or individual knowledge results from individual observations or experiments; empirical knowledge results from many such experiments and observations; scientific knowledge, finally, is that knowledge which [in addition to these] also includes the *reason* for the being and can be combined with other such pieces of scientific knowledge.[19]

Although this is one of the clearest statements of its kind, one can find a great many similar theoretical declarations in the philosophical works of the time. Without any doubt, Greek scholars honoured the new celestial mechanics and the new experimental philosophy that stemmed from Newton's synthesis; they were also eager to represent such findings and their cognitive dynamics in their works. But how did they appreciate the cognitive enterprise of the new natural philosophy? What value did they attach to it and to what extent did they perceive themselves as part of it? The picture that can be drawn from their various statements is that, beyond a manifest praise of the moderns, they perceived themselves as seekers after a deeper kind of natural truth, which would transcend the level of mere appearances and would drive at the heart of nature's secrets. The word nature itself (*physis*) was, for the most part, used in an Aristotelian sense to denote the deep *causal structure* either of individual beings or of all beings as an efficiently organized (in the sense of by an efficient cause) whole. According to the above definition

[19] 'Gnosis estin i enargis ton onton katalipsis. Kai meriki men, é atomiki i ek merikoteras paratirisis é piras prokiptousa; empiriki de, i pollas piras kai paratirisis simperilamvanousa; kai epistimoniki telos, i kai ton logon tou gignoskomenou, kai meta allon epistimonikon gnoseon sindedemeni ousa' (Karas and others 2003, 77; translation and emphasis are ours).

what the moderns did was at best empirical knowledge, while the goal of Greek-speaking scholars was real 'scientific' knowledge.

Undoubtedly, Greek-speaking scholars shared with other European scholars the desire to inaugurate an intellectual enterprise that would address the current condition of philosophy. The question that they faced, however, was not about the acceptance or rejection of a new philosophical system, but about the way in which they would revive and broaden the scope of contemporary philosophy. Some European philosophers performed unheard of actions to establish a new edifice in philosophy. They were experimentalists trying to unveil the laws of Nature, which would disclose to them important aspects of divine design, but only those that God would allow man to become acquainted with. Others formulated mathematically the regularities that they had discovered and expected geometry, algebra and, above all, the calculus, the 'mathematical fiction' of the time, to lead them to a more secure type of knowledge. Both enterprises were rather distant from the style of philosophizing practised by Greek-speaking scholars. Neither experimental empiricism nor abstract mathematical contemplation fitted this particular style. They were closer to a third group of philosophers who trusted that only metaphysics could lead natural enquiry towards a really secure haven, in the (strictly technical) sense that only metaphysics could provide the proper philosophical devices for causal thinking (Ahnert 2004). Thus, what Greek-speaking scholars intended was the upgrading of their traditional philosophical context through the incorporation of the most precious pieces of modern knowledge. They never meant to incorporate 'Newtonianism' as an integrated whole that would comprise both actual findings and methods of inquiry. Most likely, they did not even perceive it to be serious philosophy at all. However highly they esteemed Newton's contribution, the new natural philosophy was for them a mode of investigation, which enriched philosophy with new findings, but was itself in severe need of philosophical supervision, properly to accommodate such findings to the traditional metaphysical discourse about nature. Thus, Greek-speaking scholars focused on the selection of theories and facts; they even praised the fresh air brought by novel methods of inquiry; but they predominantly kept for themselves the role of supervisor, who would pave the way for a final *philosophical* synthesis, par excellence. Their philosophical training and good command of ancient sources, coupled with knowledge of the new scientific attainments, rendered them suitable for this intellectual task.

This perspective may significantly change our idea about the intellectual attitude of eighteenth-century Greek-speaking scholars towards Newtonianism. Many historians believe that, although Greek-speaking scholars didn't really embrace the new scientific method, they did their best to spread it and, under the historical circumstances in which they found themselves (Ottoman rule, poor material conditions, lack of proper institutions), this suffices to offer them a kind of historical vindication. In the light of the discussion above, however, it becomes clear that it was not the difficulty of following, or their inability or unwillingness to follow, the new developments that kept Greek-speaking scholars on the periphery of modern scientific discourse. On the contrary, they assumed a patronizing role for themselves and it was this role, in fact, that resulted in their marginalization as, in the course of time, the desire for a systematic organization of natural philosophy yielded to the demand for a formal organization of empirical knowledge. In order to understand the relationship of eighteenth-century Greek-speaking scholars with Newtonianism, it is therefore not enough to enumerate instances of various Newtonian ideas in the works of the period. This should rather be the starting point for a more comprehensive historical investigation concerning the way in which scholars dealt with these ideas, how they appropriated them into their familiar philosophical context, and what kind of philosophical syntheses they eventually produced.[20] This kind of study may reward us not only by offering a deeper understanding of eighteenth-century Greek intellectual life, but also by shedding light on one of the many shapes into which the Newtonian synthesis shifted during its journey across a range of intellectual terrains.

[20] The purpose of a historiography based on the notion of *appropriation* is to articulate the particularities of the discourse that is developed and eventually adopted within a culture, as a result of its intersection with alternative views represented by a set of new ideas. On *appropriation* as a historiographic device in history of science, see Gavroglu and others 2008 and Patiniotis 2013. For some applications of this historiographic approach, see Gavroglu and Patiniotis 2003; Patiniotis 2007.

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