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Newton and scholastic philosophy

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Abstract. This article examines Isaac Newton's engagement with scholastic natural philosophy. In doing so, it makes two major historiographical interventions. First of all, the recent claim that Newton's use of the concepts of analysis and synthesis was derived from the Aristotelian *regressus* tradition is challenged on the basis of bibliographical, palaeographical and intellectual evidence. Consequently, a new, contextual explanation is offered for Newton's use of these concepts. Second, it will be shown that some of Newton's most famous pronouncements – from the General Scholium appended to the second edition of the *Principia* (1713) and from elsewhere – are simply incomprehensible without an understanding of specific scholastic terminology and its later reception, and that this impacts in quite significant ways on how we understand Newton's natural philosophy more generally. Contrary to the recent historiographical near-consensus, Newton did not hold an elaborate metaphysics, and his seemingly 'metaphysical' statements were in fact anti-scholastic polemical salvoes. The whole investigation will permit us a brief reconsideration of the relationship between the self-proclaimed 'new' natural philosophy and its scholastic predecessors.

Introduction

Much has been learnt in the last several decades by placing various seventeenth-century natural-philosophical innovators in the context of the scholastic philosophy that still dominated university philosophical pedagogy throughout the period.[1] It is not unfair to say, for example, that our understanding of Descartes and Hobbes has been, if not revolutionized, then at least subject to very heavy modification by a series of seminal

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An early version of this paper was delivered at the Newton's *Principia* in the Age of Enlightenment conference held at the Royal Society, 11–13 December 2013, co-organized by Mordechai Feingold and Rob Iliffe. I am very grateful to them, and to the many other delegates who asked perceptive questions. In particular, I would like to thank Steffen Ducheyne, and also Stephen Clucas, who encouraged me to re-examine the relationship between Newton and Hobbes on the issue of analysis and synthesis. The research for this article was conducted while I was a fellow of Trinity College, Cambridge, where I was fortunate enough to have daily access to Newton's books: I am very grateful to all the staff at the Wren Library. The comments of the two anonymous *BJHS* referees have also led to some important modifications. Unless stated otherwise, MS transcriptions are those published in the Newton Project: www.newtonproject.sussex.ac.uk.
References to the *Principia* are to Isaac Newton, *The Principia: Mathematical Principles of Natural Philosophy*, trans. I.B. Cohen and Anne Whiteman, Berkeley, University of California Press, 1999. Other abbreviations are: *Correspondence* = H.W. Turnbull (ed.), *The Correspondence of Isaac Newton*, 7 vols., Cambridge: Cambridge University Press, 1959–1977; CUL = Cambridge University Library; Math. papers = D.T. Whiteside, *The Mathematical Papers of Isaac Newton*, 8 vols., Cambridge: Cambridge University Press, 1967–1981; *ODNB* = *Oxford Dictionary of National Biography*, at www.oxforddnb.com.

1 For an accurate recent definition of 'scholasticism' see Richard Serjeantson, 'Becoming a philosopher in seventeenth-century Britain', in Peter Anstey (ed.), *The Oxford Handbook of British Philosophy in the Seventeenth Century*, Oxford: Oxford University Press, 2013, pp. 9–38, 14.

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studies that reveal their debts to, and relations with, the traditions of school Aristotelianism.[2]

Newton has received much less treatment in this regard. This is, perhaps, understandable. Unlike Descartes and Hobbes, Newton never produced or attempted to produce a full system of philosophy,[3] and so never had to engage with the full structure of existing systems, like the scholastic. Moreover, it might convincingly be suggested that the philosophical world in which the *Principia* (1687) was composed, revised and defended was very different to that of the 1640s and 1650s: Newton was of a generation that frequently encountered the new philosophies in a pedagogical environment,[4] and so had less cause to obsess over the strengths or deficiencies of school Aristotelianism.

Why, then, is it at all interesting or important to reflect on Newton's relation to scholastic philosophy? The first reason is biographical. The above comments notwithstanding, Newton did encounter scholastic philosophy as an undergraduate, and since the evidence for this encounter survives, and since some rather conflicting claims have been made about it, we might do well to reconsider, at least briefly, that evidence.

The second reason is historiographical. Recent years have seen some very interesting – indeed, very important – arguments about Newton's supposed debt to scholastic Aristotelian methods, specifically to neo-Zabarellan *regressus* theory (explained below). These are of importance not just for the study of Newton's intellectual development, but also because they impinge heavily on some of the most fundamental issues in his natural-philosophical methodology, especially respecting the status of causal explanation; it is thus worth treating them at some length.

Third, it will be shown that some of Newton's most famous pronouncements – both in the General Scholium appended to the second edition of the *Principia* (1713) and elsewhere – are simply incomprehensible without a quite specific knowledge of scholastic terminology and its later reception, and that this impacts in quite significant ways on how we understand Newton's natural philosophy more generally. Contrary to recent historiographical consensus, we shall find that Newton did not hold an elaborate 'metaphysics' that explained God's relationship with the world and thus the operation of forces such as gravity – rather, he despised the discipline of metaphysics, and his

2 Denis des Chene, *Physiologia: Natural Philosophy in Late Aristotelian and Cartesian Thought*, Ithaca, NY: Cornell University Press, 1996; Roger Ariew, *Descartes and the Last Scholastics*, Ithaca, NY: Cornell University Press, 1999; Cees Leijenhorst, *The Mechanization of Aristotelianism: The Late Aristotelian Setting of Thomas Hobbes' Natural Philosophy*, Leiden: Brill, 2002; an extremely useful overview appears in Michael Edwards, 'Aristotelianism, Descartes, and Hobbes', *Historical Journal* (2005), 50, pp. 449–64. I do not cite here the myriad of works that have shaped our understanding of early modern Aristotelianism: the key introduction remains Charles B. Schmitt, *Aristotle and the Renaissance*, Cambridge, MA: Harvard University Press, 1983.

3 Some recent studies have implicitly argued the contrary. Their claims are questioned below.

4 The key study remains that by Mordechai Feingold, 'The mathematical sciences and the new philosophies', in N. Tyacke (ed.), *The History of the University of Oxford*, vol. 4: *17th-Century Oxford*, Oxford: Oxford University Press, 1997, pp. 359–448; see also James Hannam, 'Teaching natural philosophy and mathematics at Oxford and Cambridge, 1500–1700', PhD thesis, University of Cambridge, 2008. More specifically see below.

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seemingly 'metaphysical' statements were, in fact, anti-scholastic polemical salvoes: a crucial fact that has been missed in all the previous literature.

Finally, the whole investigation will allow us to return to the broader picture of seventeenth-century philosophical change, and to examine how Newton's case might illuminate broader patterns of intellectual change and the relationship between the self-proclaimed 'new' natural philosophy and its scholastic predecessors.

Newton and scholastic pedagogy: the Trinity Notebook

Newton's most obvious engagement with scholastic philosophy occurred during his years as a BA student at Trinity College, Cambridge, for which the key evidence is the so-called Trinity Notebook, containing notes taken *c.*1661–1664. The document is well known: it begins with passages in Greek from Aristotle's *Organon* and Porphyry's *Isagoge*, and goes on with notes from two near-contemporary scholastic textbooks: Johannes Magirus's *Physiologiae peripateticae libri sex* (Cambridge, 1642, 1st edn 1600) and Daniel Stahl's *Axiomata philosophica* (Cambridge, 1645). To what extent do these notes – which were not published in the modern edition of the notebook, and so must still be consulted in the original manuscript in Cambridge University Library[5] – reveal much about Newton's debt to scholastic natural philosophy?

In the 1980s, William Wallace – who has examined the notes more fully than anyone else – argued that they reveal a great deal on this score, to the extent that Newton's debt to the scholastic tradition was comparable to the much more obvious debts incurred by Galileo. To take only a few examples, he speculated that Magirus's positing of a *vis insita* in the stars 'could not but have had an influence on the young Newton' and even that some of the notes from Stahl pre-empt Newton's discovery of universal gravitation.[6]

Such claims do not convince. Newton's notes from Magirus and Stahl show little independent reflection, and we may safely agree with Jed Buchwald and Mordechai Feingold's recent comment that 'Newton's absorption of scholastic material bears every sign of having been superficial'.[7] To this we might add some comparative contextual evidence. The two scholastic textbooks from which Newton took the most notes (as far as we know, barring further manuscript discoveries) were, relatively speaking, quite primitive compared to some of the textbooks being read by Newton's close contemporaries. Take, for example, Francis Willughby, who like Newton was at Trinity, albeit slightly earlier, between 1652 and 1660, and who would also become an important member of the Royal Society. During his university days Willughby read some rather

5 CUL MS Add. 3996, fols. 3r–10v, 16r–26v, 43r–71v. A very high-quality reproduction is available at http://cudl.lib.cam.ac.uk/view/MS-ADD-03996/1. The much-cited modern edition is J.E. McGuire and M. Tamny (eds.), *Certain Philosophical Questions: Newton's Trinity Notebook*, Cambridge: Cambridge University Press, 1983.

6 W.W. Wallace, 'Newton's early writings: beginning of a new direction', in G.V. Coyne, SJ, M. Heller and J. Życiński (eds.), *Newton and the New Direction in Science*, Vatican City: Specola Vaticana, 1988, pp. 23–44, 30, 34–35 and *passim*.

7 Jed Buchwald and Mordechai Feingold, *Newton and the Origin of Civilization*, Princeton, NJ: Princeton University Press, 2013, p. 15.

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more advanced scholastic texts, such as Marcus Wendelin's *Contemplationes Physicae* (Cambridge, 1648, 1st edn 1625).[8] Indeed, there is considerable evidence of Wendelin's work being used by Cambridge students: one surviving copy, for example, belonged to John Patrick, having been used by him in 1650, either at the very end of his studies for a BA, or at the very start of those for an MA.[9]

If these students were reading texts like Wendelin's much more advanced textbook at quite late stages of their student careers, Newton's case seems very different: as far as the evidence we have goes, he was simply taking basic notes from much more introductory texts. That is not to say that the notes are of no significance at all for his mature writings: as we shall see below, he would later attack scholastic concepts that he could have encountered in both Magirus and Stahl. But even those attacks will be revealed to have been haphazard and commonplace.

Analysis, synthesis and the *regressus* tradition

A much more subtle, significant and philosophically precise argument for the putative influence of neo-scholastic philosophy on Newton's mature thought than that of Wallace has recently been made in the pioneering study by Steffen Ducheyne. He argues that Newton's natural-philosophical methodology – specifically his self-proclaimed use of the method of analysis and synthesis – was deeply indebted to the scholastic tradition of *regressus*, developed by Aristotelians in sixteenth-century Padua, most famously by Jacopo Zabarella, as that tradition was manifested in some seventeenth-century English philosophy textbooks. Most broadly, this was a tradition of thinking about the nature of demonstration in which one first derives an inference from an observed effect to its cause (*demonstratio quia*), and then reverses the procedure, and infers from the cause to the effect (*demonstratio propter quid*), leading to truly 'scientific' (that is to say, causal) knowledge of the effect.[10] If Ducheyne is correct, it would have a very major impact indeed not only on our understanding of Newton's intellectual formation, but also on the importance of the *regressus* tradition to early modern natural-philosophical change more generally. It thus seems worth treating the issue at some length.

8 See Willughby's commonplace book, Nottingham University Library, MS Mi LM 15/1, p. 572. The discovery of this evidence is entirely that of Richard Serjeantson, who was kind enough to share it with me, and whose broader findings on this score will appear as 'The education of Francis Willughby', an early version of which I have been fortunate to benefit from.

9 Patrick's copy is CUL, shelfmark Peterborough 2.2, inscribed on the title page, 'Ex libris Iohannis Patricke Reginalensis. Iuly: 1. 1650' – Patrick took his BA from Queens' in 1650, MA in 1654. J.A. Venn, *Alumni Cantabrigienses*, 10 vols., Cambridge: Cambridge University Press, 1922–53, vol. 3, p. 318.

10 Steffen Ducheyne, 'Newton's training in the Aristotelian textbook tradition: from effects to causes and back', *History of Science* (2005), 43, pp. 217–37; Ducheyne, *The Main Business of Natural Philosophy: Isaac Newton's Natural-Philosophical Methodology*, Dordrecht: Springer, 2012, pp. 3–36. The classic studies of *regressus* are J.H. Randall, *The School of Padua and the Emergence of Modern Science*, Padua: Editrice Antenore, 1961; Nicholas Jardine, 'Galileo's road to truth and the demonstrative regress', *Studies in History and Philosophy of Science* (1976), 7, pp. 277–318 and very many since; for England see now Marco Sgarbi, *The Aristotelian Tradition and the Rise of British Empiricism: Logic and Epistemology in the British Isles (1570–1689)*, Dordrecht: Springer, 2013.

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From around the 1690s onwards, Newton tended to describe his natural-philosophical methodology as proceeding by a dual process of analysis and synthesis. A particularly famous summative quotation can be found in Query 31 of the *Opticks*:

> As in Mathematicks, so in Natural Philosophy, the Investigation of difficult Things by the Method of Analysis, ought ever to precede the Method of Composition. This Analysis consists in making Experiments and Observations, and in drawing general Conclusions from them by Induction, and admitting of no Objections against the Conclusions, but such as are taken from Experiments, or other certain Truths. For Hypotheses are not to be regarded in experimental Philosophy. And although the arguing from Experiments and Observations by Induction be no Demonstration of general Conclusions; yet it is the best way of arguing which the Nature of Things admits of, and may be looked upon as so much the stronger, by how much the Induction is more general. And if no Exception occur from Phænomena, the Conclusion may be pronounced generally. But if at any time afterwards any Exception shall occur from Experiments, it may then begin to be pronounced with such Exceptions as occur. By this way of Analysis we may proceed from Compounds to Ingredients, and from Motions to the Forces producing them; and in general, from Effects to their Causes, and from particular Causes to more general ones, till the Argument end in the most general. This is the Method of Analysis: And the Synthesis consists in assuming the Causes discover'd, and establish'd as Principles, and by them explaining the Phænomena proceeding from them, and proving the Explanations.[11]

Newton here, as elsewhere,[12] states that as in mathematics, so in natural philosophy, investigation should proceed first by analysis, which consists of making experiments and observations, generating general conclusions by induction; in synthesis (or composition), those general conclusions are taken as principles and new phenomena are derived and proved by them.

The long-standing view in the literature has been that Newton was here applying the terminology of classical and contemporary mathematics to natural philosophy more generally.[13] But Ducheyne seeks to refute this, through an argument which – while rich and complex – can be fairly summarized as consisting of three main parts:

1 Newton's version of analysis/synthesis was incompatible with the mathematical tradition, primarily because 'Newton's conception of natural philosophy is explicitly causal … a feature that is obviously lacking in the mathematical tradition of analysis–synthesis'.[14]

11 Newton, *The Opticks*, New York: Dover, 1952 (based on the 1730 edn), pp. 404–405. The passage first appears in *Optice*, London, 1706, p. 347. The transcription in Ducheyne, *The Main Business of Natural Philosophy*, op. cit. (10), p. 19, contains a misleading error, as the last 'Analysis' is replaced with 'Synthesis'.

12 Other key loci include *Principia*, pp. 382, 943 (the latter is from the General Scholium); *Math. Papers*, vol. 7, pp. 212–216 (a draft for a tract on 'Analysis Geometrica', *c.*1691), 249–251 (a draft preface to 'Geometriae Libri tres', early 1690s); vol. 8, 442–459 (= *Principia*, pp. 49–54) (drafts for a new preface to the *Principia*, 1710s); the drafts for the above *Opticks* passage in CUL Add. 3970, fols. 242v–243r, 480v; that adduced in Jean Pelseneer, 'Une opinion inédite de Newton sur l'analyse des anciens' à propos de l'*Analysis Geometrica* de Hugo de Omerique', *Isis* (1930), 14, pp. 155–165. The most important studies are Alan Shapiro, 'Newton's "experimental philosophy"', *Early Science and Medicine* (2004), 9, pp. 185–217; and Niccoló Guicciardini, *Isaac Newton on Mathematical Certainty and Method*, Cambridge, MA: MIT Press, 2009, pp. 309–327.

13 E.g. Peter Dear, *Discipline and Experience: The Mathematical Way in the Scientific Revolution*, Chicago: The University of Chicago Press, 1995, p. 240.

14 Ducheyne, *The Main Business of Natural Philosophy*, op. cit. (10), p. 8.

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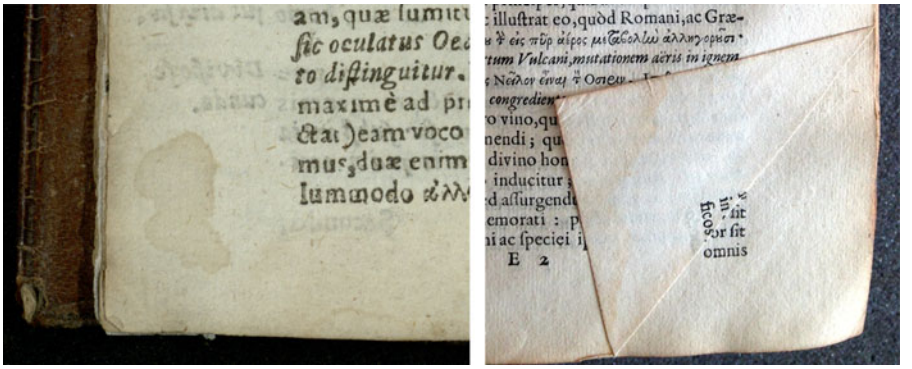


Figure 1. Left: Newton's copy of Smith's *Aditus ad logicam* (Trinity, NQ 9.166), showing p. 12, one of the supposedly dog-eared pages (according to Ducheyne). Right: Newton's actual practice from much later, in his copy of G.J. Vossius's *Theologia gentilis* (NQ 8.46), p. 35.

2 Newton thus drew on Aristotelian scholastic *regressus* theory: 'Newton conceptualised natural-philosophical analysis and synthesis in line with the tenets of the Aristotelian textbook tradition on the matter'.[15]
3 A specific text – Samuel Smith's *Aditus ad logicam* (1st edn 1613) – 'can quite safely be considered an actual source for Newton's ideas on natural philosophical analysis and synthesis'.[16]

For reasons that will shortly become clear, I would like to proceed through these three parts in reverse order. We begin with the final claim: that Newton relied on Samuel Smith's *Aditus ad logicam* as the key source for his *regressus* arguments. Newton owned a copy of the sixth edition of 1649, and it survives among his books in Trinity College, Cambridge: Ducheyne claims that 'there is serious evidence that Newton thoroughly studied this work',[17] leading him to the very assertive conclusion quoted above. But as always with evidence of early modern reading, we have to be extremely careful; on this occasion, slightly more caution might have yielded a different conclusion.

For example, Ducheyne asserts that the book 'shows numerous signs of dog-earring' (Newton's favoured method of bookmarking), and lists forty-four pages where he claims to discover such signs.[18] But the book in fact contains no dog-earing at all, only the typical signs of wear and tear that one finds on almost any early modern book, as is clear from a comparison of the book with another that Newton certainly did later dog-ear (Figure 1). Indeed, the most reliable evidence points to the fact that Newton only started folding pages to specific passages somewhat later than the 1660s.[19]

15 Ducheyne, *The Main Business of Natural Philosophy*, op. cit. (10), p. 18.
16 Ducheyne, *The Main Business of Natural Philosophy*, op. cit. (10), p. 16.
17 Ducheyne, *The Main Business of Natural Philosophy*, op. cit. (10), p. 16.
18 Ducheyne, *The Main Business of Natural Philosophy*, op. cit. (10), p. 16 n. 74.
19 Scott Mandelbrote, personal communication. I am very grateful to him for informing me of his findings on this matter, findings which he intends to publish in due course.

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Figure 2. Left: Smith's 'Arbor Porphyriana' (between pp. 32 and 33 in the *Aditus*). Right: A close-up of the Arbor from Newton's Trinity notebook (CUL MS Add. 3996, fol. 2r). Note the differences. But Newton's divisions *were* present in other near-contemporary versions of the Arbor.

Some of Ducheyne's other claims also fail to stand up to detailed scrutiny. He claims, for example, that the drawing of the 'Arbor Porphyriana' – that is to say, the Tree of Porphyry traditionally used to classify the Aristotelian categories – that we find at the beginning of the Trinity Notebook is 'based on Samuel Smith's division', as found in the version of the 'Arbor' in the *Aditus ad logicam*. But if we compare carefully Newton's tree with that in Smith, we find that they are in fact quite different. To take only one example, Newton's contains divisions for simple and mixed non-living bodies, whereas Smith's does not (Figure 2). But such divisions are present in the version of the 'Arbor' in other contemporary pedagogical texts, such as Melchior Cornaeus's *Curriculum philosophiae Peripateticae* (1657), among many others.[20] This is not to argue that Cornaeus was Newton's source, but simply to point out that it seems much more likely that something else like his work (rather than Smith's) was a direct source for Newton.

The reader may consider these bibliographical points to be relatively minor. But another deserves our serious attention. Ducheyne claims that the markings and notes on the Trinity copy of Smith's textbook – which are indeed clustered around the chapter on *demonstratio* that contains the discussion of *regressus* – are Newtonian. But here we encounter a major stumbling block, for it is quite clear that the handwriting is not Newton's (Figure 3).[21] In short, we must conclude that there is no evidence that

20 See Paul Richard Blum, *Studies on Early Modern Aristotelianism*, Leiden: Brill, 2012, pp. 275–314 ('God and individuals: the Porphyrian tree in seventeenth/eighteenth-century philosophy'), at pp. 284, 301–302, for Cornaeus.

21 I am very grateful to David McKitterick, my colleague at Trinity, for confirming my own judgement that the handwriting is not Newton's.

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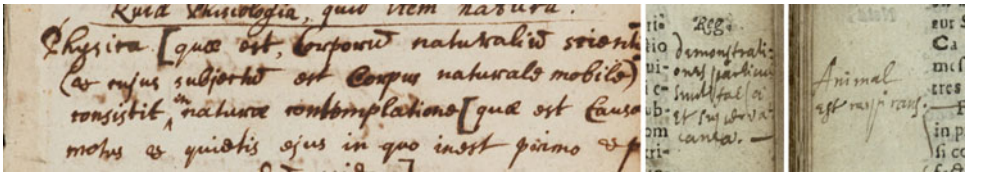


Figure 3. Left: Newton's handwriting in the 1660s (CUL MS Add. 3996, fol. 16r). Right: two examples of the very different handwriting in NQ 9.166.

Newton was particularly inspired by Smith's book, or even that he read it with any care, if he read it at all.[22]

We see, then, that there is no bibliographical, material or intellectual biographical evidence for Newton's deep engagement with the *regressus* methodology of textbook scholasticism. This leaves us with Ducheyne's first two arguments, which are purely philosophical–intellectual in nature. His second point is that Newton must have been drawing on Aristotelian *regressus* because his methodological position, like that of the Paduans and their followers, was a causal one. As he summarizes, 'Newton conceptualised natural-philosophical analysis and synthesis in line with the tenets of the "Aristotelian" textbook tradition on the matter'.[23] But if we compare Newton's words with those of the *regressus* theorists we find far more differences than similarities. First of all, where Newton foregrounds the language of analysis and synthesis, the Aristotelian *regressus* theorists placed emphasis not on this (Smith, for example, does not use the terms at all) but on the classically Aristotelian language of explanation τοῦ ὅτι and τοῦ διότι, generating *demonstratio propter quod* and *demonstratio propter quid* in Latin. Even more importantly, all this is part of the process of constructing a syllogism. If we take Smith as a typical example, at the beginning of the chapter on *demonstratio* that contains his discussion of *regressus*, he summarizes that logical demonstration involves forming a syllogism, beginning with true premises and deducing necessarily true conclusions.[24] Newton, of course, never says anything like this: he never talks about syllogisms or about these different types of demonstration. Indeed, in the quotation from Query 31 that we met earlier, Newton explicitly says that his method 'be no Demonstration', whereas the whole point of *regressus* was that it offered *demonstratio* – for example, this is the chapter title of the section in which Smith's discussion is

22 That he did not read it during his undergraduate days is supported by the fact that the (admittedly unclear) inscription on the inside flyleaf seems to read 'John Parke … 1659 (1660)', again in a hand that is without doubt not Newton's. Could this be the John Parke who matriculated at King's in 1639, securing his BA in 1643 and MA 1646, or the John Parkes who matriculated at John's in 1660? Venn, op. cit. (9), vol. 3, pp. 305, 310.

23 Ducheyne, *The Main Business of Natural Philosophy*, op. cit. (10), p. 18.

24 Samuel Smith, *Aditus ad logicam*, Oxford, 1649 (1st edn London, 1613), pp. 121 ('Demonstrationis definitio petitur aut a fine eius ad collimat, vel a materia ex qua constituitur. Finis eius est Scientia; unde Demonstratio ab *Aristotele* dicitur Syllogismus, qui scientiam parit') and 127 ('Demonstratio est Syllogismus scientificus, qui constat ex veris, primis, immediatis, notioribus & prioribus & causis conclusionis. Prima conditio est, ut constet ex veris, *seu ut alii addunt,* necessario veris …'). See further Sgarbi, op. cit. (10), pp. 147–150.

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to be found. All this is not to say that it was impossible for natural philosophers to adopt *regressus* theory while dropping the syllogistic aspect – a good example is William Harvey, in the methodological preface to his *Exercitationes de generatione animalium* (1651).[25] But even he (imbued with the Paduan methodological ideas during his time there) retained the references to Aristotle, the language of τοῦ ὅτι and τοῦ διότι demonstration, and the whole complex mechanism of mental abstraction that the Aristotelians believed this to involve. Newton simply never does any of this.

To this it might be replied that Newton's vision of analysis and synthesis has to be derived from the Aristotelian textbook tradition because it simply is not compatible with the other suggested source: the mathematical tradition as we understand it (this is Ducheyne's first point).[26] This may be true – Newton certainly does not use the terms in precisely the sense they were used by Pappus (who, it should be said, is very ambiguous on the issue) and others whom he claimed to be emulating (see below) – but it is surely beside the point, precisely because Newton did not have our understanding of ancient mathematics, but an early modern one. As is now well established, there had been, since the mid-sixteenth century, a concerted attempt to increase the status of mathematics by presenting it as a causal *scientia* both equal in status to natural philosophy and capable of offering explanations within natural philosophy. This attempt had been made first by a group of Jesuits like Christopher Clavius, then by Galileo, then by many others, including in England Thomas Hobbes and Newton's mentor Isaac Barrow.[27] As Alan Shapiro, Mary Domski and Niccolò Guicciardini (among others) have shown, Newton almost certainly inherited a stake in this debate from Barrow, his early mentor at Trinity.[28] Guicciardini above all has charted how Newton's 1690s mathematical manuscripts built on the preface to the *Principia*, which presented the genre of the work as 'rational mechanics' supposedly in the vein of ancient geometers like Pappus, and that it was in these manuscripts that Newton developed his vision of

25 William Harvey, *Exercitationes de generatione animalium*, London, 1651, 'Praefatio', esp. sig. [B4]r–v (manipulating *An. Post.*, 99b26–100a9). See Charles B. Schmitt, 'William Harvey and Renaissance Aristotelianism: a consideration of the *Praefatio to "De generatione animalium"* (1651)', in G. Keil and R. Schmitz (eds.), *Humanismus und Medizin*, Weinheim: Acta Humaniora, 1984, pp. 117–138, esp. 129–132; Roger French, *William Harvey's Natural Philosophy*, Cambridge: Cambridge University Press, 1994, pp. 313–315; Sgarbi, op. cit. (10), pp. 180–184.

26 Ducheyne, *The Main Business of Natural Philosophy*, op. cit. (10), pp. 7–8 (see also the quotation keyed to n. 14 above).

27 Key studies are Paolo Mancosu, *Philosophy of Mathematics and Mathematical Practice in the Seventeenth Century*, Oxford: Oxford University Press, 1996, pp. 10–33; Rivka Feldhay, 'The use and abuse of mathematical entities: Galileo and the Jesuits revisited', in P. Machamer (ed.), *The Cambridge Companion to Galileo*, Cambridge: Cambridge University Press, 1998, pp. 80–145; for the wider sociological dimension see Mario Biagioli, 'The social status of Italian mathematicians, 1450–1600', *History of Science* (1989), 27, pp. 41–95.

28 Guicciardini, op. cit. (12), pp. 291–328; Mary Domski, 'Newton as historically minded philosopher', in M. Dickson and M. Domski (eds.), *Discourse on a New Method: Reinvigorating the Marriage of History and Philosophy of Science*, Chicago: OpenCourt, 2010, pp. 65–90; James W. Garrison, 'Newton and the relation of mathematics to natural philosophy', *Journal of the History of Ideas* (1987), 48, pp. 609–627; Dear, op. cit. (13), pp. 210–244.

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natural philosophy being founded on the ancient method of analysis and synthesis.[29] As far as Newton was concerned, mathematics was directly connected to physical reality, and 'mathematical representations should be closely aligned with the properties of physical bodies and their motions',[30] geometrical objects having been generated mechanically, as they were for Barrow too.

This much is well established. But it still leaves us with an important unresolved question. Barrow, after all, did not use the language of analysis or synthesis, and his history of mathematics was very different from Newton's, focusing not on Pappus and the putative tradition of rational mechanics, but rather on Aristotle and some other classical Greek mathematicians and natural philosophers. Why, then, did Newton turn away from Barrow's formulation to the language of analysis and synthesis and his own historical justification for it? Here I offer an explanation that no previous scholar (as far as I know) has broached: that while Newton would have agreed with the broad principles behind Barrow's vision of the history of mathematics, he may well have been deeply unconvinced by the specifics of Barrow's history, and that Newton's consequent shift away from those specifics explains his turn to the language of analysis and synthesis.

In his Lucasian lectures, Barrow had argued, 'Mathematics is co-extended with physics', and the division of mathematics into pure and mixed was an artificial historical development introduced first by Aristotle and then by Geminus, when in reality all mathematics always abstracted from physical bodies.[31] While this is structurally very similar to Newton's argument about mechanics in the preface to the *Principia* and the 1690s manuscripts, had Newton investigated Barrow's actual history in any detail – as he is likely to have done – he may well have found it very unconvincing.

Take, for example, Barrow's argument that all the ancients believed that mathematics offered certainty in natural philosophy. To justify this, Barrow claimed that Aristotle had inherited this belief from his predecessors, citing passages from *De caelo* and the *Metaphysics*. But in reality Aristotle had in those loci argued something completely different, insisting only on the accuracy of mathematics. Indeed, he quite clearly opined, 'The minute accuracy of mathematics is *not* to be demanded in all cases, but only in the case of things which have no matter':[32] exactly the opposite of what Barrow was claiming for him.

Such misreadings are even more apparent in Barrow's treatment of number theory. Barrow believed so strongly in the pre-eminence of geometry as the science of real magnitude that he even subsumed arithmetic under geometry and claimed that this had been the case in antiquity. This claim caused immediate headaches, for all the ancient mathematicians had quite clearly differentiated arithmetic from geometry: most importantly

29 On the role of mechanics see further Alan Gabbey, 'The *Principia*: a treatise on "Mechanics"?', in P.M. Harman and A.E. Shapiro, eds., *The Investigation of Difficult Things: Essays on Newton and the History of the Exact Sciences*, Cambridge: Cambridge University Press, 1992, pp. 305–322.

30 Guicciardini, op. cit. (12), p. 313.

31 Isaac Barrow, *Lectiones mathematicae XXIII*, London, 1685, pp. 5–75. For the full details of Barrow's history of mathematics see Dmitri Levitin, *Ancient Wisdom in the Age of the New Science: Histories of Philosophy in England, c.1640–1700*, Cambridge: Cambridge University Press, 2015, pp. 315–321.

32 Barrow cites *De caelo*, III.7, 306a18–21 and *Met.* II.3, 995a15–17; the translation from the latter is that of W.D. Ross, *Aristotle's Metaphysics*, Oxford, 1953, p. 52 ('τὴν δ' ἀκριβολογίαν τὴν μαθηματικὴν οὐκ ἐν ἅπασιν ἀπαιτητέον, ἀλλ' ἐν τοῖς μὴ ἔχουσιν ὕλην'), my emphasis.

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both Aristotle and Euclid supported a strict division between number and magnitude, a division reflected in the separation of the geometric and arithmetic material in Euclid's *Elements*.[33] Barrow was aware of this problem, and sought to alleviate it by manipulating some of the evidence. Instead of citing the mathematical tradition as it was commonly understood, Barrow cited a very ambiguous fragment from the obscure Pythagorean Archytas, which stated that arithmetic was only the 'sister' to geometry. Yet had Barrow been honest, he would have admitted that the same source which contained this fragment – Nicomachus' *Introduction to Arithmetic* – also stated that Archytas believed that 'arithmetic seems to be far superior to the other arts', geometry in particular.[34] Barrow was effectively twisting the truth on its head, and this kind of scholarship is impressive neither by modern nor by early modern standards: certainly, it was an idiosyncratic reading in the seventeenth century.[35]

In short, Newton had very good reasons to think that he needed a rather different history of mathematics to that offered by Barrow, even if they were making broadly the same methodological point. Moreover, Newton also had very good reasons to settle on the language of analysis and synthesis, because plenty of others before him had already used it to make precisely the same point. We might here quote only one author whose works Newton certainly read as a student,[36] Walter Charleton:

> The Method of Demonstration, you know, is twofold; the one by Analysis, the other by Synthesis … And this Latter is that, which the Ancient Geometricians generally made use of in their Writings; not that they were ignorant of the other: But (as I conceive) because they valued it so highly, as that they desired to reserve it to themselves, as a great Secret, and too noble to be prophaned by vulgar communication … as for the *Analytical* method; I would not have you despair of seeing it in some measure accommodated to the subject [i.e. the nature of the soul].[37]

Like Newton, Charleton believed that the ancient mathematicians possessed an esoteric method of analysis but that they generally used synthesis in the writings;[38] like Newton,

33 See Katherine Neal, *From Discrete to Continuous: The Broadening of Number Concepts in Early Modern England*, Dordrecht: Kluwer, 2002, pp. 12–27 (the ancient sources), 121–122 (on Barrow, although given his use of Archytas it is not quite correct to say that 'he could … cite no examples of a classical source that agreed with his point of view').

34 Barrow, *Lectiones*, op. cit. (31), pp. 33–34. The source is Nicomachus, *Introduction to Arithmetic*, I.3.4 (= *Introduction to Arithmetic*, trans. M.L. D'Ooge, London: Macmillan, 1926, pp. 184–185). Barrow cites fr. 1 ('ταῦτα γὰρ τὰ μαθήματα δοκοῦντι ἔμμεναι ἀδελφεά'), but Archytas' real belief is given in fr. 4 ('καὶ δοκεῖ ἁ λογιστικὰ ['logistics', i.e. arithmetic] ποτὶ τὰν σοφίαν τῶν μὲν ἀλλᾶν τεχνῶν καὶ πολὺ διαφέρειν, ἀτὰρ καὶ τᾶς γεωμετρικᾶς ἐναργεστέρω πραγματεύεσθαι ἃ θέλει'). The Archytas fragments were published by Henri Estienne in an edition of Aristotle and Theophrastus (1557), and they appeared in the many popular collections of Pythagorean fragments published in the sixteenth and seventeenth centuries. See J. Hankins and A. Palmer, *The Recovery of Ancient Philosophy in the Renaissance*, Florence: Olschki, 2008, p. 51.

35 For the recognition that the ancients had made arithmetic prior to geometry, using some of the standard sources, see e.g. John Wallis, *Mathesis Universalis* [1657], in Wallis, *Opera mathematica*, 3 vols., London, 1693–1699, vol. 1, p. 53.

36 McGuire and M. Tamny, op. cit. (5), pp. 26–42, 336–338.

37 Walter Charleton, *The immortality of the human soul*, London, 1657, pp. 63–65.

38 An early modern commonplace: see e.g. René Descartes, *Regulae ad directionem ingenii*, in *Oeuvres de Descartes*, ed. Charles Adam and Paul Tannery, 12 vols., Paris: Léopold Cerf, 1897–1910, vol. 10, pp. 376–377; John Wallis to Gerard Langbaine *et al.*, 20 December 1656, in *The Correspondence of John Wallis*,

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he also believed that the analysis–synthesis method could be 'accommodated' to the study of a natural-philosophical subject: the soul.[39]

Charleton, in turn, may well have been influenced by his acquaintance Thomas Hobbes. On the surface, there are very strong similarities between Newton and Hobbes: not just the use of analysis–synthesis, but also the mathematical physics it is used to defend, including a dislike for the unnecessary abstractions supposedly introduced into analysis by the modern algebra (of course, very ironic in Newton's case), a subsequent belief that analytic geometry added little to ancient methods, and the belief that arithmetic depended on geometry.[40] As with Newton, there have been some ambitious attempts to connect Hobbes to the Paduan *regressus* theorists.[41] And just as with Newton, these do not stand up to detailed scrutiny.[42] As Noel Malcolm has summarized,

> This sort of conceptual 'compounding' and its converse, conceptual resolution, provided the primary model for Hobbes's theory of resolutive–compositive method – a method which … owed almost nothing to Galileo and very little to the Paduan tradition of commentary on Aristotle. The use of the terms 'resolutio' and 'compositio' was immensely widespread, across a whole range of disciplines: they were simply the Latin equivalents of the Greek terms 'analysis' and 'synthesis', terms used in the Galenist tradition of diagnosis and prognosis, and in the Euclidean tradition of the methodology of mathematical problems.[43]

ed. P. Beeley and C.J. Scriba, 3 vols., Oxford: Oxford University Press, 2003–2012, vol. 1, p. 265; Fermat to Digby, February 1657, *The Correspondence of John Wallis*, pp. 275–276; John Wallis, *A treatise of algebra*, London, 1685, pp. 1, 3–4. This belief was reinforced by Fermat's new edition of Diophantus (1670): see e.g. John Collins to John Gregory, 25 March 1671, in S. Jordan Rigaud (ed.), *The Correspondence of Scientific Men of the Seventeenth Century*, 2 vols., Oxford: Oxford University Press, 1846, vol. 2, p. 218.

39 For the place of the soul in early modern taxonomies of knowledge see Richard Serjeantson, 'The soul', in D.M. Clarke and C. Wilson (eds.), *The Oxford Handbook of Philosophy in Early Modern Europe*, Oxford: Oxford University Press, 2011, pp. 119–141.

40 McGuire and Tamny, op. cit. (5), pp. 219–121, thus strongly insisted that Hobbes was Newton's direct source, an insistence that seems rather over-eager. For Hobbes, Douglas Jesseph, *Squaring the Circle: The War Between Hobbes and Wallis*, Chicago: The University of Chicago Press, 1999, pp. 189–246, supplies all the key loci, so I do not give them here.

41 J.W.N. Watkins, *Hobbes's System of Ideas: A Study in the Political Significance of Philosophical Theories*, London: Hutchinson, 1965, pp. 47–65; Aldo Gargani, *Hobbes e la scienza*, Turin: Einaudi, 1971, pp. 32–96.

42 See the very astute points made in J. Prins, 'Hobbes and the school of Padua: two incompatible approaches of science', *Archiv für Geschichte der Philosophie* (1990), 72, pp. 26–46, esp. 30, 40; also Jesseph, op. cit. (40), pp. 238–240; Richard A. Talaska, 'Analytic and synthetic method according to Hobbes', *Journal of the History of Philosophy* (1988), 26, pp. 207–237, esp. 236.

43 Noel Malcolm, *Aspects of Hobbes*, Oxford: Oxford University Press, 2002, pp. 146–155 ('Hobbes's science of politics and his theory of science'), 153. See also the similar conclusion applied more generally in Hans-Jürgen Engfer, *Philosophie als Analysis: Studien zur Entwicklung philosophischer Analysiskonzeptionen unter dem Einfluss mathematischer Methodenmodelle im 17. und frühen 18. Jahrhundert*, Stuttgart: Frommann-Holzboog, 1982, p. 71 ('Die Verwechslung und Vermischung dieser verschiedenen mathematischen Methodenmodelle führt zu erheblichen Komplikationen auch in der sich an ihnen orientierenden philosophischen Methodendiskussion, die nicht zuletzt dadurch zustande kommen, daß in den zugrunde liegenden mathematischen Modellen dieselben methodologischen Schlüsselbegriffe verwendet werden. Insbesondere gilt dies für die noch bei Kant zentralen Begriffe "analytisch" und "synthetisch" bzw. "resolutio" und "compositio", die in den verschiedenen Konzeptionen unterschiedliche

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Since the initial reception of the Greek mathematical writings in the sixteenth century was partially shaped 'through their real or perceived compatibility with the Aristotelian ideal of science',[44] it is not surprising that the terms were used rather promiscuously. But in the absence of direct evidence for Newton's debt to the *regressus* tradition – an absence that we have confirmed – the safest option seems to be simply to believe what Newton himself said: that he saw himself to be operating in a mathematical tradition stemming from Pappus.

There is, of course, a larger philosophical significance to all this. Ducheyne's attempt to find a scholastic Aristotelian lineage for Newton's methodology is part of a broader project to present Newton as a firm causal realist, in opposition to the phenomenalist reading of Newtonian physical explanation. Relying in particular on the previously quoted passage from Query 31 to the *Opticks*, he claims that when Newton spoke of 'forces' in the *Principia* he was really speaking of 'proximate causes' as the concept had been used by Smith (i.e. that inverse-square centripetal forces are the proximate causes of universal gravitation). With Smith – and thus with the concept of 'proximate causes' (never used by Newton in print[45]) – we have already dispensed. We can consequently more generally question the causal reading of Newton on force. The language of analysis and synthesis that Newton began using in the 1690s manuscripts related most directly to the few methodological parts of the *Principia*: the preface – where we will remember that Newton links his methodology to the putative rational mechanics of the ancient geometers – and the Scholium at the end of Book I, Section 11. Nowhere here does Newton intimate that 'he had unveiled gravity as primary or proximate cause for the heavenly and terrestrial motions'.[46] Rather, he informs us, he had 'found propositions'; that he had not 'inquir[ed] into the causes or species of the force, but consider[ed] only their quantities, directions, and effects'; that he had 'not yet learned the cause of gravity from the phenomena'; that he had 'discover[ed] the forces of nature from the phenomena of motions'; and that he spoke of attraction and impulse 'considering … not the species of forces and their physical qualities but their quantities and mathematical proportions'.[47] Analysis, Newton confirmed in a draft

Funktionen übernehmen und sich dementsprechend schon in der Methodologie des 17. Jahrhunderts durch die Vieldeutigkeit ihrer Verwendung auszeichnen').

44 Engfer, op. cit. (43), p. 69 ('Die Rezeption dieser mathematischen Methodenschriften im 16. Jahrhundert wird zunächst durch ihre wirkliche oder vermutete Kompatibilität mit dem aristotelischen Wissenschaftsideal').

45 He used it twice in MS. First, in the unpublished preface to the *Principia* of the 1710s: *Principia*, pp. 53–54. Ducheyne, *The Main Business of Natural Philosophy*, op. cit. (10), p. 22, makes a great deal of this passage, but apart from it remaining unpublished, we should also note that it is not clear from it that Newton thinks that in his own work he has ever moved towards the discovery of causes (proximate or otherwise), only that that is a desirable aim. As he said again and again, he had not discovered the cause of gravity. Just as importantly, it appears to be connected – like all his causal talk – to the rhetoric of philosophy revealing the 'first cause' (God): see the use in CUL MS Add. 3965, fol. 359v (a draft for the General Scholium). See further below.

46 Ducheyne, *The Main Business of Natural Philosophy*, op. cit. (10), p. 24.

47 See, respectively, the unpublished preface to the *Principia* (CUL MS Add. 3968, fol. 109, *c.* 1710), in *Principia*, pp. 50–51, 52, 53; 'Preface', *Principia*, p. 53; Scholium on Book I, Section 11, *Principia*, p. 588. See further *Principia*, p. 408 ('I use interchangeably and indiscriminately words signifying attraction, impulse, or any sort of propensity toward a center, considering these forces not from a physical but only from a mathematical point of view'). See also the discussion in George E. Smith, 'The Methodology of the

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preface to the first edition of the *Opticks* composed *c.*1703–1704, leads only to 'the general properties of things', which one then only 'assum[es]' as causes during the process of synthesis.[48]

Indeed, Newton only really emphasized the language of 'causes' in the passage from Query 31, and in the many manuscript drafts for it which are repeatedly quoted by Ducheyne, because at this point he was also making the rhetorical point that natural philosophy leads to knowledge of the operation of God, the 'first cause'.[49] Even nearby in the *Opticks*, Newton, when not required to make these rhetorical concessions to theological language, clearly differentiated between gravity as a 'principle' or 'law of nature' whose 'Truth appear[ed] to us by Phaenomena', and its 'Causes', which are 'not yet discover'd'.[50] By the process of analysis he had discovered 'properties', but not causes.[51] And it was for this, after all, that he was chastised again and again by Leibniz and by others, who claimed that Newton's explanation of gravity was not philosophical at all. Had Newton been influenced by Aristotelian scholastic *regressus* theory, he would surely have simply made this clear in his responses. Instead, he continued to insist on the new, mathematical nature of his natural philosophy: after all, it was precisely this new type of explanation that his 'mathematical principles of natural philosophy' entailed.

Indeed, Newton seems to have been concerned from an early stage in his natural-philosophical career to avoid – or at least treat with extreme caution – the language of causes. In his earliest defences of his theory of colour from the early 1670s, Newton was already using the rather idiosyncratic concept of 'properties' that we have just encountered him using on several occasions in his post-*Principia* phase. His discovery, he announced, 'consists only in some properties of light', a claim that he repeated again and again.[52] Even in the drafts to the *Opticks* passage on which Ducheyne

Principia', in I.B. Cohen and G.E. Smith, *The Cambridge Companion to Newton*, Cambridge: Cambridge University Press, 2002, pp. 138–173, 143 ('In Newton's hands *force* is a flagrantly theoretical quantity'), 148–149, 151. Ducheyne, *The Main Business of Natural Philosophy*, op. cit. (10), p. 26, attempts to negate this by claiming that what Newton is saying is that 'while an account of the remote cause of celestial and terrestrial motions is explicitly absent from the *Principia*, it is nowhere implied thereby that Newton also avoided an account of their proximate cause', but then why do none of these Newton loci refer to anything like 'proximate causes'? (Of course, given that we now know that there is no evidence of Newton reading the scholastic works in which such a concept is to be found, this is not particularly surprising.)

48 CUL MS Add. 3970, fol. 480v. On this text see J.E. McGuire, 'Newton's "Principles of Philosophy": an intended preface for the 1704 *Opticks* and a related draft fragment', *BJHS* (1970), 5, pp. 178–186.

49 As well as the very many drafts in CUL MS Add. 3970, see CUL Add. MS 3968.39, fol. 586v, quoted at Ducheyne, *The Main Business of Natural Philosophy*, op. cit. (10), p. 22.

50 Newton, *Opticks*, op. cit. (11), pp. 401–402.

51 Newton, *Opticks*, op. cit. (11), p. 405.

52 Newton to Oldenburg, 19 June 1672, in *Correspondence*, vol. 1, p. 164. The first sentence of the *Opticks* repeats the claim that Newton is searching for 'Properties of Light' (p. 1). I was rather proud of spotting this repeated usage, only then to realize that it had also been spotted much earlier than me, and explained in illuminating detail, in A.E. Shapiro, *Fits, Passions, and Paroxysms: Physics, Method, and Chemistry and Newton's Theories of Colored Bodies and Fits of Easy Reflection*, Cambridge: Cambridge University Press, 1993, pp. 13–23 (tracing the continuous use of the concept from the *Optical Papers* through to Newton's later works).

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relies, we see Newton agonizingly equivocating over whether to use 'properties/principles' rather than 'causes'.[53]

Given all the evidence presented above, we can say with some certainty that Newton was not a causal realist in the Aristotelian sense, and – with much more caution – we might also suggest that the phenomenalist reading of Newtonian method is not so misguided. It should be made clear that there can be no doubt that Newton was rather indiscriminate in his terminology. But equally there can be no doubt that he did not think of the immediate results of his mathematical physics as causes (proximate or otherwise) in an Aristotelian scholastic sense.[54] As much is clear from the famous part of the General Scholium where Newton announced that although he had not found the cause of gravity, he had still shown that it exists – or more accurately that 'these *properties* of gravity' do.[55] As we shall have further cause to point out, Newtonian methodological statements were often geared more towards polemic than towards internal precision or consistency. As the manuscript evidence shows, the polemical force of the passages on analysis and synthesis was directed more towards the debate on the certainty of mathematics than towards the status of causation (although Newton would surely have also believed that his physicalist conception of mathematics mitigated the 'non-philosophical' implications of this). Piercing through the polemic to the reality of Newton's practice is not simple (and often impossible), but the one thing that seems certain is that there is, for the time being, no hard bibliographical or biographical evidence of Newton engaging deeply with the scholastic Aristotelian *regressus* tradition.

The rejection of metaphysics

The foregoing argument has been a negative one: Newton did not use Aristotelian scholastic *regressus*, he did not hold to an Aristotelian scholastic conception of 'cause', and the claim that he did depends on a bibliographical and palaeographical misreading. The following argument is also negative, but in a different sense, for it will be shown that famous passages in the General Scholium and elsewhere that have been adduced to claim that Newton possessed a sophisticated 'metaphysics' were in fact designed not to make any positive claims about God's relationship with the world (or any positive

53 See e.g. CUL MS Add. 3970, fol. 243r (draft for Query 23/31): '<The business of Experimental Philosophy is only to find out by experience & Observation <not how things were created but> what is the> present frame of nature … This inquiry must proceed first by Analysis in arguing from effects to causes & from compositions to components <ingredients>. And when we have found <the principles> [the causes <& ingredients of things we may> proceed by <Synthesis> from those Principles'. No *regressus* theorist would ever have used 'causes' interchangeably with 'ingredients'.

54 This much seems to be admitted in Ducheyne, 'Newton's training', op. cit. (10), p. 228: 'Newton introduced a new causal entity, "Universal Gravitation", which was completely different from the Aristotelian notion of cause'. But if it is not to be understood in the Aristotelian sense, then why not simply adopt the phenomenological reading? The conclusion in Guicciardini, op. cit. (12), pp. 323–324, seems far more likely (it accounts for the differences between the various mathematical passages and the more causal-sounding passages in the Queries to the *Opticks*), as long as 'Aristotelian' is taken in a very wide rhetorical sense, not the precise sense meant by Ducheyne.

55 *Principia*, p. 943, my emphasis.

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claims at all), but – unbeknown to the many modern scholars who have attempted to analyse them – to attack very specific aspects of scholastic philosophy.

How we have reached the stage where so many scholars now assume that Newton had an elaborate metaphysics is unclear.[56] Their interpretations vary, but what they tend to mean by this is that Newton held some kind of non-empirical vision of God's presence and action in the world that shaped the rest of his natural philosophy, and perhaps explains such issues as physical causation, because God may in one way or another act as the medium through which matter interacts. But as I have shown elsewhere, Newton quite explicitly rejected the discipline of 'metaphysics', considering it to lie at the origins of both theological and natural-philosophical error; because of this rejection, he was deliberately agnostic about the precise mechanisms of God's operation in the world (to step beyond that agnosticism would be to descend into the dreaded metaphysics).[57] Here we might quote only one of the myriad of passages in which Newton rejected the discipline:

> What is taught in metaphysics, if it is derived from divine revelation, is religion; if it is derived from phenomena through the five external senses, it pertains to physics; if it is derived from knowledge of the internal actions of our minds through the sense of reflection, it is only philosophy about the human mind and its ideas as internal phenomena, and likewise pertains to physics. To dispute about the objects of ideas except insofar as they are phenomena is dreaming. In all philosophy we must begin from phenomena and admit no principles of things, no causes, no explanations, except those which are established through phenomena.[58]

Newton could hardly be clearer that he had no time for metaphysics as a discipline.

In opposition to such a reading, it might be claimed that these were just throwaway polemical commonplaces (for example, the anti-Cartesian implications of the above passage are clear), and that in reality Newton did actively practise metaphysics. Before we turn to a rebuttal of such a claim, we need to ask what the concept actually meant

56 Prominent examples include the collected essays in J.E. McGuire, *Tradition and Innovation: Newton's Metaphysics of Nature*, Dordrecht: Kluwer 1995; Howard Stein, 'Newton's metaphysics', in Cohen and Smith, op. cit. (47), pp. 256–307; Mary Domski, 'Newton's empiricism and metaphysics', *Philosophy Compass* (2010) 5, pp. 525–534; Andrew Janiak, *Newton as Philosopher*, Cambridge: Cambridge University Press, 2008; Eric Schliesser, 'Without God: gravity as a relational quality of matter in Newton', in D. Jalobeanu and P. Anstey (eds.), *Vanishing Matter and the Laws of Motion: Descartes and Beyond*, London: Routledge 2011, pp. 80–102, esp. 95 (and other essays); Hylarie Kochiras, 'Gravity and Newton's substance counting problem', *Studies in History and Philosophy of Science* (2009) 40, pp. 267–280, esp. 270 (and other essays).

57 Dmitri Levitin, 'The historical assumptions behind the General Scholium', in S. Ducheyne, S. Mandelbrote and S. Snobelen, eds., *Newton's General Scholium after 300 Years* (forthcoming) – the following discussion expands significantly on the final section of this chapter. I would go as far as to say that no major natural philosopher between 1500 and 1800 said more often than Newton that they were not doing metaphysics.

58 CUL MS Add. 9597.2.11, fol. 2r: 'Quod in Metafysica docetur <& si a revelatione deducitur religio esse>, si a Phaenomenis per sensus quinque externos, a Physicam pertinent, si a cognitione actionum internarum mentis nostrae per sensum reflexionis, philosophia est de sola mente humana & ejus ideis <tanquam Phaenomenes internas> & ad Physicam <item> pertinent. De Idearum objectis disputare nisi quatenus sunt phaenomena <somnium est>. In omni Philosophia incipere debemus a Phaenomenis, & nulla admittere <rerum> principia nullas causas nullas explicationes nisi quae per phaenomena stabiliuntur'. This text is not published in the Newton Project, and I have consulted the original in CUL. The translation is that offered in I.B. Cohen, 'A guide to Newton's *Principia*', in *Principia*, p. 54.

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to Newton and his contemporaries. Here the scholastic context is crucial, for contrary to Howard Stein's much-cited article on 'Newton's metaphysics', we cannot simply use the definition of 'metaphysics' from the 1911 edition of the *Encyclopaedia Brittanica*, but we must identify what early modern philosophers themselves meant by the term.[59]

Aristotle had been famously ambiguous about what metaphysics constituted. Sometimes he equated it with 'first philosophy', understood as the study of being qua being or of universal principles, but at other times he equated it with 'theology' – the Greek θεολογικα – understood as a science of eternal causes and immaterial entities.[60] This ambiguity generated much dispute in the medieval and Renaissance Aristotelian tradition, and continued through to seventeenth-century philosophical pedagogy. To offer a very rough taxonomy (which makes allowances for many important exceptions), the Scotist tradition in which figures like Francisco Suárez operated tended to see metaphysics as the science of being in general, a move that was also followed by notable Lutheran metaphysicians such as Christoph Scheibler, whose *Metaphysica* (1617) became probably the most popular metaphysics textbook in seventeenth-century England.[61] On the other hand, a line of thinkers stemming primarily from one of Suárez's Jesuit counterparts, Benito Pereira, postulated that 'metaphysics proper' had as its subject only God and immaterial being, and thus equated it with *theologia naturalis*. This definition was taken up by some Calvinist metaphysicians, such as Rudolph Goclenius, and in England it was embraced perhaps most passionately by none other than Henry More, who spent the first three chapters of his *Enchiridion metaphysicum* (1671) arguing that metaphysics was not a *philosophia prima* or a science of being qua being, but directly equivalent to *theologia naturalis* as the study of immaterial substances.[62] Descartes, as always, wanted to have his cake and eat it: as the full title of his *Meditations* (1641) made clear, his 'metaphysics' both was primarily concerned with

59 Stein, op. cit. (56), p. 256. It should be added that a non-anachronistic history of metaphysics in seventeenth-century Europe is a major desideratum.

60 The key loci are *Met.* IV, 1003a21 and VI, 1026a19–20. For the early modern reception the key study remains Hans Reiner, 'Die Entstehung der Lehre vom bibliothekarischen Ursprung des Namens Metaphysik: Geschichte einer Wissenschaftslegende', *Zeitschrift für philosophische Forschung* (1955), 9, pp. 77–99, at 79–80, supplemented in many very useful ways by Leijenhorst, op. cit. (2), pp. 17–55.

61 See Ian Hunter, 'The university philosopher in early modern Germany', in C. Condren, S. Gaukroger and I. Hunter (eds.), *The Philosopher in Early Modern Europe*, Cambridge: Cambridge University Press, 2006, pp. 35–65, 62–63. On the importance of Scheibler's work in seventeenth-century Oxford (the first Oxford edition was published in 1637, with additions by the young Thomas Barlow) see Richard Serjeantson, 'Hobbes, the universities and the history of philosophy', in Condren, Gaukroger and Hunter, op. cit., pp. 113–140, 131. For a very late English manifestation of this definition of metaphysics see also [Daniel Whitby?], *Brevissimum metaphysicae compendium, secundum mentem nominalium*, Oxford, 1690, pp. 1–2 (I adopt the speculative attribution to Whitby from the ESTC, but I have been unable to find any evidence for it – the work may as well be treated as anonymous).

62 Charles Lohr, 'Metaphysics', in E. Kessler and Q. Skinner (eds.), *The Cambridge History of Renaissance Philosophy*, Cambridge: Cambridge University Press, 1988, pp. 537–638, 631–632; J.A. van Ruler, 'Franco Petri Burgersdijk and the case of Calvinism within the neo-scholastic tradition', in R.P. Bos and H.A. Krop (eds.), *Franco Burgersdijk (1590–1635)*, Amsterdam: Rodopi, 1993, pp. 37–65, 41. For More see *Enchiridion metaphysicum, sive de rebus incorporeis*, London, 1671, 1–42, esp. 1 ('METAPHYSICA *est Ars recte contemplandi res Incorporeas quatenus e Lumine Naturae Facultatibus nostris innotescunt. Itaque* Metaphysica *Theologia* quasi quaedam Naturalis est').

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immaterial substance, and was also a *philosophia prima* – as we know, it was indeed a propaedeutic to the rest of his philosophy.[63]

Newton made it so abundantly clear that he was not doing 'metaphysics' in a Cartesian sense that we need not consider the possibility at much length.[64] But what about the possibility that Newton had a 'metaphysical' vision of how God interacted with the world, and that his metaphysics was thus broadly equivalent to natural theology? (It could still thus function as a propaedeutic to the rest of his philosophy.) Once again, Newton said quite clearly that he was *not* doing this, and that it was the attempts to do this, and specifically to explain the nature of God's omnipresence, that had led both to idolatry and to natural-philosophical error. Instead, he was deliberately agnostic about precisely how God was omnipresent in the world. This is clear enough from this draft to the Queries to the *Opticks*:

> The first thing to be done in Philosophy is to find out all the general laws of motion on which the frame of nature depends … And in this search metaphysical arguments are very slippery. A man must argue from phenomena. We find in ourselves a power of moving our bodies by our thoughts, and see the same power in other living creatures, but how this is done and by what laws we do not know. By this instance, and by that of gravity, it appears that there are other laws of motion unknown to us. We cannot say that all Nature is not alive … Our senses tell us not the essences of things and Metaphysical arguments about them are very slippery … And it is safest to argue from Phenomena and stop where Phenomena are wanting.[65]

As we see, according to Newton the rejection of metaphysics means that we simply cannot know how several natural phenomena occur, including the interaction between soul and body and the action at a distance that causes gravitational attraction. From phenomena the world may appear 'alive', but to speculate further and to try to explain this would be to return to the dreaded and misleading discipline of metaphysics. Newton, on his own terms, was not a metaphysician, but deliberately and self-consciously agnostic about issues of the sort he considered metaphysical.[66]

If the above reading is correct, however, it might be thought to leave us with a major dilemma. For there are several passages, much adduced and analysed in the secondary literature, in which Newton seems to offer some much more positive and non-agnostic statements about the relationship of God and the world. The first is from the General Scholium: 'God is omnipresent not only virtually but also substantially'.[67] (A better

63 *Meditationes de prima philosophia in qua Dei existentia et animae immortalitas demonstratur*, Paris, 1641. There are some very interesting comments on Descartes as part of the tradition of making God and immaterial substances the subject of metaphysics in Joël Biard, 'God as first principle and metaphysics as a science', in R.L. Driedman and L.O. Nielsen (eds.), *The Medieval Heritage in Early Modern Metaphysics and Modal Theory, 1400–1700*, Dordrecht: Kluwer, 2003, pp. 75–97, esp. 92–94.

64 See e.g. CUL MS Add. 3970.3, fol. 249r; CUL MS Add. 95972.14, fol. 4r; CUL MS Add. 3970.3, fols. 621v–622r, discussed further in Levitin, op. cit. (57).

65 CUL MS Add. 3970.3, fol. 620v. I have heavily normalized and modernized this text. A full discussion appears in Levitin, op. cit. (57).

66 Of course, Newton also speculated on natural-philosophical explanations for gravity, e.g. the electrical spirit of the end of the General Scholium. For the methodological status of such speculations – of which the Queries to the *Opticks* are archetypal – see Shapiro, op. cit. (12), p. 188.

67 Newton, *Principia*, p. 941.

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translation, the philosophical significance of which will appear imminently, is 'God is omnipresent not only in power [*virtus*] but also in substance'). The second is from the much-discussed 'De gravitatione' manuscript, where Newton says variously that space is an 'emanative effect of God', that 'space is an emanative effect of the first existent being', and that 'space is … the emanative effect of an eternal and immutable being'.[68]

At first glance (and scholars have directed many more glances than that at these passages) these seem to be much more positive statements than the agnosticism that I am attributing to Newton. But is this really the case? Here the scholastic context proves crucial, for it emerges that without it these statements are quite simply incomprehensible.

No one, to my knowledge, has ever asked what, contextually speaking, Newton might have meant when he attacked the idea that God was only present virtually, or 'in power'. But if we turn to the tomes of the late scholastics, the answer becomes quite clear. Newton was dismissing the commonplace scholastic argument that substances – especially immaterial substances – may have a 'virtual extension'; that is to say, that they operate through their power – *virtus* – without having the properties of normal extended substances like parts and divisibility. To give three almost random but very popular examples, the Jesuit Pedro Hurtado de Mendoza devoted a whole section of his 1624 philosophy textbook to 'Judging the doctrine of the virtual extension of points', concluding that he 'admits virtual extension in spiritual substances, but rejects it in matter', and then suggesting that virtual extension could explain the classic problem of how incorporeal objects could act on corporeal ones.[69] One finds very similar arguments in a myriad of other texts, such as the popular textbooks of Pedro de Fonseca (1599–1604) and Luis de Ribas (1643).[70] Nor was it only used by scholastics; Descartes, for example, used it in his correspondence with Henry More (a text known to Newton).[71]

Unsurprisingly, the ubiquity of this concept led to it being attacked by many of the anti-scholastic *novatores*. The vast majority of them offered variants of the same criticism: that virtual extension was meaningless, for extension was either real or no

68 Newton, 'De gravitatione', in Newton, *Philosophical Writings*, ed. Andrew Janiak, Cambridge: Cambridge University Press, 2004, pp. 21, 25, 26.

69 Pedro Hurtado de Mendoza, *Universa philosophia … nova editio*, Lyon, 1624 (1st edn 1617), pp. 343–345 ('Expenditur doctrina de virtuali punctorum extensio'), concluding on p. 343b: 'Virtualem item extensionem admitto in substantia spirituali: at in materiali recuso'. For body and soul see p. 344b.

70 Pedro da Fonseca, *Commentariorum Petri Fonsecae … in Metaphysicorum Aristotelis Stagiritae libros*, 3 vols., Cologne, 1599–1604 (this was the first edition to contain the full three volumes), vol. 3, p. 379a: 'Hanc autem virtualem extensionem dari a forma incorporea, & inextensa nullum est incommodum: praesertim cum omnis forma, quae in se una est, det substantiae quam constituit virtualem potentiarum multitudinem, quae ex essentia a se composita quasi nascuntur'. See the valuable discussion in Dennis Des Chene, *Life's Form: Late Aristotelian Conceptions of the Soul*, Ithaca, NY: Cornell University Press, 2000, pp. 90–91. Luis de Ribas, *Summa theologica*, Lyon, 1643, pp. 82–83 (the chapter is entitled 'Quid sit Immensitas, & an soli Deo conueniat').

71 Descartes to Henry More, 15 April 1649, in *Oeuvres de Descartes*, op. cit. (38), vol. 5, p. 342: 'Quantum autem ad me, nullam intelligo nec in Deo nec in Angelis vel mente nostra extensionem substantiae, sed potentiae duntaxat; ita scilicet ut possit Angelus potentiam suam exerere nunc in maiorem, nunc in minorem substantiae corporeae partem; nam, si nullum esset corpus, nullum etiam spatium intelligerem, cui Angelus vel Deus esset coextensus'.

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extension at all. This was proclaimed by Descartes's friend and editor Louis de la Forge,[72] but also by Descartes's experimentalist critic Pierre Petit, who not only suggested that *extensio virtualis* is scholastic nonsense, but also even went on to claim that the concept threatened rather than preserved God's omnipresence, which it had been used to defend by scholastic philosophers.[73] Petit was elected FRS in 1667, and it is no surprise that we also find the concept of virtual extension attacked by English natural philosophers of the second half of the seventeenth century. To take only one example, the physician Samuel Haworth argued that if the soul is not properly extended it cannot exert any action upon the body: the idea that the soul 'operated upon the Body' virtually was simply a typical scholastic absurdity.[74]

Placed in this context, Newton's dismissal of virtual extension/extension in power thus now appears only as a rather commonplace anti-scholastic salvo. This seems to be unequivocally confirmed by a passage from the 'Tempus et locus' manuscript from the 1690s, where, as part of a long condemnation of scholastic philosophy, Newton attacks the idea that God is only omnipresent as regards power: 'Let them [i.e. the scholastics] therefore consider whether it is more agreeable to reason … that God is everywhere as regards power [*virtus*] and nowhere as regards substance, or that God's

72 Louis de la Forge, *Traitté de l'esprit de l'homme, de ses facultez et fonctions, et de son union avec le corps*, Paris, 1666 (1st edn 1664), p. 187: 'Ils disent pour éviter cette difficulté que l'Esprit n'est pas estendu réellement, mais virtuellement, & que cette estenduë virtuelle suffit pour ester coestendu (permettez-moi ce mot) & present localement à un Corps qui a une extension réelle. Je ne les accuserai pas ici de n'entendre pas ce qu'ils veulent dire, quoi qu'il y ait lieu de croire que cela leur arrive assez souvent, lorsqu'ils allèguent de belles paroles auxquelles aucune idée qu'ils puissant expliquer ne répond dans leur esprit; mais accordons-leur qu'ils comprennet fort clairement ce que c'est qu'une étendue virtuelle, il faut aussi qu'ils m'accordent qu'on ne saurait concevoir aucune sorte d'extension, sans concevoir en meme temps plusieurs parties, dont l'une soit hors de l'autre; or dès qu'on aperçoit qu'une partie est hors d'une autre, on voit par meme moyen que ce sont deux parties dont l'une peut être conçue sans l'autre, et par conséquent exister séparément; et ainsi c'est une extension réelle, et ce sont des parties réelles qu'ils attribuent à l'esprit, lorsqu'ils pensent ne lui donner qu'une étendue et des parties virtuelles. Il est donc impossible de comprendre l'union de l'esprit et du corps selon les principes de la philsoophie de l'Ecole'.

73 Pierre Petit, *De extensione animae et rerum incorporearum natura libri II*, Paris, 1665, pp. 49–50: 'Si enim ubique totus, ubi partes? Qui igitur ita indivisibilis est, quomodo extensus dici potest? nempe virtuali extensione: ita enim respondent. At, quid est virtualis extensio, nisi Deum indivisibili essentia ita in omnibus operari, ac si revera per universum esset Orbem extensus? Ad potentiam igitur vimque agendi virtualis illa extensio recidit, quando in ipsa substantia nihil apparet, nisi simplicissimum & summe individuum, ita omnem excludens extensionem, ut nec ejus partes ullae vel mente designari possint. Caeterum, divinam potentiam ad omnia extendi loca, omnesque Mundi partes complecti nemo negat. Quin non alia est apud Theologorum praestantissimos immensitatis notio. "Deus" (inquit D. Thomas) "in omnibus est per essentiam, quia substantia ejus omnibus adest, ut causa essendi"'. Petit's marginal note is to 'distinct. 37', which is most likely Aquinas's commentary on Lombard's *Sentences* (which is divided into '*distinctiones*'), but Aquinas certainly does not say there what Petit claims he does. Some linguistic similarities can be found in Aquinas, *Quaestiones disputatae de veritate*, q. 10a. 11 ad 7, but there again Aquinas says something different. I am very grateful to the second of the *BJHS* referees for assisting me in thinking through this unsolved puzzle.

74 Samuel Haworth, *Anthropologia, or, A philosophic discourse concerning man. Being the anatomy both of his soul and body*, London, 1680, p. 66. This is part of the chapter defending the soul's extension (pp. 58–66). Little is known about Haworth: a skeletal introduction is available in M.S.R. Jenner, 'Haworth, Samuel', *ODNB*.

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power should subsist everywhere in the divine substance … and exist nowhere separately.'[75]

Far from engaging in an elaborate metaphysical enterprise, then, Newton was simply pointing out that his defence of God's omnipresence was qualitatively different from that of his scholastic predecessors. This is no concession to occasionalism, materialism, Neoplatonism, Spinozism or any of the other positions that Newton has been asserted to have come close to in the recent literature.[76] It is a polemical self-defence against those who might accuse him of not properly accepting God's omnipresence, as one could accuse the scholastics and Descartes.

That still leaves us with 'De gravitatione', and the idea that we find there that space is an 'emanative effect' of God. The only precursor to Newton in using the term that half a century of scholarship has examined is Henry More, who in his *Immortality of the soul* (1659) states that an 'emanative effect' is the product of a cause that acts simply by existing:

> By an *Emanative Cause* is understood such a Cause as meerly by Being, no other activity or causality interposed, produces an Effect. That this is possible is manifest, it being demonstrable that there is *de facto* some such Cause in the world; because something must move it self. Now if there be no Spirit, Matter must of necessity move it self, where you cannot imagine any activity or causality, but the bare essence of the Matter from whence this motion comes.[77]

Unfortunately, this has once again generated the rather misleading impression that Newton's discussion of emanation must have been informed by idiosyncratic Neoplatonic traditions, or even by Spinoza.[78]

Such an impression is misleading because if we delve into the scholastic textbooks we find that More was not at all unique or idiosyncratic, for this was again a very common concept. In scholastic texts the language of 'emanative cause and effect' had a very precise meaning: an 'emanative cause' was, alongside its counterpart the 'active cause', one of the first subset of efficient causes. It was a cause that functioned simply though the existence of an object, from the action of which was generated an 'emanative effect'. The standard example almost always offered to explain this was that the heat produced by fire was an emanative effect, whereas the heat of any object heated by the same fire was an *active* effect. As with virtual extension, the real philosophical purpose was usually to explain the action of non-extended substances like the soul.

It is precisely this use that we find in some of the most popular scholastic manuals and textbooks of the seventeenth century, such as Rudolph Goclenius's *Lexicon philosophicum* (1613),[79] Franco Burgersdijck's *Institutionum logicarum libri duo*

75 Isaac Newton, 'Tempus et locus' (CUL MS Add. 3965, early 1690s), quoted and trans. in J.E. McGuire, 'Newton on place, time, and God: an unpublished source', *BJHS* (1978), 11, pp. 114–129, 121.

76 E.g. in Janiak, op. cit. (56), p. 166 n. 5.

77 Henry More, *The immortality of the soul*, London, 1659, pp. 32–33.

78 For the former suggestion see e.g. many of the essays in McGuire, op. cit. (56); for the latter, Schliesser, op. cit. (56), esp. p. 88.

79 Rudolph Goclenius, *Lexicon Philosophicum quo tanquam clave philosophiae fores aperuntur*, Frankfurt, 1613, p. 146 (entry on 'Emanare'): 'Emanare est immediate essentiam comitari, tamen sine respectu existentiae, & ante existentiam, & sine respectu causae externae'.

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(1626),[80] or Adriaan Heereboord's *EPMHNEIA logica* (1651),[81] all of which were republished in England and used in English philosophical pedagogy throughout the century.[82] Nor was the use of the concept limited to pedagogical texts, for it appeared in otherwise very different philosophical works by the likes of Zabarella and Johann Heinrich Alsted.[83] Most interestingly for us, the undergraduate Newton made a note on the scholastic concept of emanation when reading Stahl's *Axiomata*.[84] This may thus be one of the very rare cases when we can directly connect the Trinity Notebook to the later Newton, although, as we have seen, the concept was so commonplace that that does not really reveal very much.

We have seen, then, that in 'De gravitatione' Newton was using a standard scholastic concept. Moreover, it was a concept which, like *extensio virtualis*, had been mocked by plenty of non-scholastic philosophers, whether on the Continent or in England.[85] This conclusion leaves us with two obvious questions. First, can Newton's use of the concept in 'De gravitatione' be used as a guide for his later statements about the relationship between God and the world (such as those in the General Scholium), as it has been by a host of interpreters? Here the answer is surely 'no': everything we know about Newton's intellectual biography suggests that he would have balked at using concepts that he recognized as scholastic in his mature writings. In support of this, it is important to recognize that 'emanative causation' had a direct relationship with the other concept that we have just found Newton rejecting: virtual extension. Fonseca, for example, when explaining how the soul interacts with the body, claimed that it is '"eminently" or

80 Franco Burgersdijk, *Institutionum logicarum libri duo*, Cambridge, 1637, pp. 69–70 (in Chapter 17, on efficient cause): 'Primo, dividitur causa efficiens in activam, quae effectum causat mediante actione; & in eam, a qua res immediate emanat, ac sine ulla actione proficiscitur'. Burgersdijk then goes on to give the example of fire and heat ('ignis est causa emanativa proprii caloris; at est causa activa caloris in alio'). For the popularity of Burgersdijk's work in seventeenth-century English pedagogy see Mordechai Feingold, 'The humanities', in Tyacke, op. cit. (4), pp. 211–357, 294–296.

81 Adriaan Heereboord, *EPMHNEIA Logica: sive synopseos logicae Burgersdicianae*, London, 1651, pp. 36–38. There were further English editions in 1658, 1662 and 1676 (London) and 1663, 1670 and 1680 (Cambridge). See also Heereboord, *Meletemata philosophica*, Amsterdam and London, 1680 (1st edn 1654), pp. 263–265.

82 For a native example, albeit one taken from the work of Bartholomäus Keckermann, see [Henry Ainsworth/Zachary Coke], *Art of logick*, London, 1657 (1st edn 1654), p. 54. That the work is derived from that of Keckermann was first noted in Richard Serjeantson, 'Testimony and proof in early modern England', *Studies in the History and Philosophy of Science* (1999) 30, pp. 195–236, 207 n. 63. The English abridger's identity is discussed in James S. Measell, 'The authorship of the *Art of Logick*', *Journal of the History of Philosophy*, 15 (1977), pp. 321–324.

83 Johann Heinrich Alsted, *Encyclopaedia septem tomis distincta*, 2 vols. (Herborn, 1630), vol. 1, p. 613a (again using the standard fire–heat example). For Zabarella see W.A. Wallace, *Prelude to Galileo: Essays on Medieval and Sixteenth-Century Sources of Galileo's Thought*, Dordrecht: Reidel, 1981, p. 113.

84 CUL MS Add. 3996, fol. 46v: ('Omnis causa agit. [hoc ffalsum est in Materiali, fformali, et causa finali. Si etenim hae causae agunt sunt omnes efficientes, nam omnis causa agens est efficiens. Omnis vero & sola causa efficiens agit hoc est causa physica (nam Gubernatoris somnum, vel negligentiam, esse causam [one illegible deleted word] naufragii fit naturaliter.) (Object. fforma & essentia rei est causa efficiens propriorum accidentium: non vero per veram actionem sed per emanationem tantum et resultantiam …').

85 E.g. Gideon Harvey, *Archeologia philosophica nova*, London, 1663, pp. 75–76; Joseph Glanvill, *The vanity of dogmatizing*, London, 1661, p. 37.

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"virtually" capable of all the effects found in lesser forms'.[86] Closer to home, Henry More, when responding to Petit, claimed something very similar, even asserting that this fact meant that God's extension had to be understood not in a physical but in a 'metaphysical' sense.[87] But as we have seen time and time again, Newton rejected metaphysical approaches to these problems. It seems just as unlikely that he would have seriously considered the use of the scholastic concept of 'emanative effect' in his mature works (of course, this is why he never did use the words).

But this leaves us with the obvious second question: why did the young Newton use the scholastic language of 'emanative causation'? One very simple answer is that 'De gravitatione' was written at a relatively early stage of Newton's philosophical development, around 1670, when he had not yet fully arrived at his anti-metaphysical and anti-scholastic dogmatism. This conclusion can be somewhat contextually refined. Mordechai Feingold has discovered a manuscript that shows that 'De gravitatione' was very likely part of a course of lectures that Newton delivered in Cambridge in 1671.[88] It would be far more understandable for Newton to use scholastic metaphysical terminology that he did not personally agree with – terminology that his students would have imbibed repeatedly through the textbooks of the arts course – in such a pedagogical setting. No less a philosopher (and friend of Newton) than John Locke would later recommend precisely this practice. Like Newton, he thought metaphysics a nonsensical discipline that should be abandoned by all serious modern thinkers. Nonetheless, he recommended its incorporation into a course of philosophy study for young students.[89]

If I am right, then, here we finally have Newton being a scholastic philosopher, but only when he was teaching. In his own mature natural philosophy there was no place for metaphysics, scholastic or otherwise.

Broader conclusions

It is time to stop attempting to use 'De gravitatione' as some kind of metaphysical key to Newton's mature natural philosophy. Some of our colleagues who approach Newton from a philosophical perspective have said that the dating of the work is irrelevant, because it still represents Newton's central philosophical concerns. But if Feingold and

86 See Des Chene, op. cit. (70), pp. 90–91.

87 More, *Enchiridion metaphysicum*, in *Opera omnia*, vol. 1, London, 1679, p. 148.

88 Mordechai Feingold, *The Newtonian Moment: Isaac Newton and the Making of Modern Culture*, New York, 2004, pp. 26–27. The key evidence is a letter from the important Trinity College Greek scholar Thomas Gale to Edward Bernard, Bod. MS Smith 8, fol. 147r. Feingold suggests that the final version of 'De gravitatione' is a later one, because of 'its invocation of the concept of inertia, a term not used by Newton before the mid-1680s' (p. 194 n. 38). This reasoning (albeit not with Feingold in mind) is convincingly challenged in J.A. Ruffner, 'Newton's *De gravitatione*: a review and reassessment', *Archives of the History of the Exact Sciences*, 66 (2012), pp. 241–264, 256. I thus accept Feingold's argument about the early 1670s pedagogical origins of the work, but, on the basis of the evidence gathered by Ruffner, reject the claim that the final version stems from the 1680s: the whole document should be seen as a product of lectures delivered in the early 1670s.

89 For disparaging comments on metaphysics see John Locke, *An essay concerning human understanding*, London, 1690, pp. 240, 310; for the recommendation to study it, see [Locke], *Some thoughts concerning education*, London, 1693, p. 225 (albeit taking into account the strong qualification at 197).

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I are correct, the issue is not simply that it is an early text; rather, it is that it may well be a text that is not at all representative of Newton's true opinion, but rather a pedagogical exercise – modern academics hardly need reminding that one's actual beliefs are not always represented in, and are often contradicted by, one's pedagogical pronouncements. If we are to reconstruct the historical Newton, the genre of various texts matters as much as their chronological context.

This leads to a second, connected point (one that I am by no means the first to make).[90] This is that we should treat Newton's methodological statements with extreme care. The more research is conducted, the more it appears that Newton used methodological statements not really to explain precisely what he was doing, but to score polemical points. To the anti-Cartesian and anti-Leibnizian points that other scholars have identified, I hope that I have now been able to add the anti-scholastic ones.

Finally, I would like to come back briefly to the broader issue raised in the Introduction, and to place Newton in the wider context of the history of scholastic philosophy in seventeenth-century England. Since the work of Charles Schmitt, it has been common to emphasize the continuing relevance of the Aristotelian tradition(s) to the *novatores* of the seventeenth century.[91] As was stated at the outset, this has borne very fruitful results. Nonetheless, it should not obscure the fact that anti-scholasticism was a very real, and a very powerful, force, which – however gradually – genuinely eroded the relevance of Aristotelian philosophy.[92] In the case under consideration here, it does seem that Newton was rather detached from scholastic philosophy, however much he was prepared to attack sporadically some of its more awkward concepts. Already in his earlier works, Newton saw Aristotelian scholastic hylomorphism not as something to be refuted, but only to be mocked.[93] The vitality of early modern Aristotelianism notwithstanding, late seventeenth-century natural philosophers, at least in England, were not particularly concerned with relating their research to the textbooks that they had learnt from in their university days. *Pace* Wallace, there seems little hope of relating Newton's undergraduate notes to his natural philosophy.

This late seventeenth-century distance between school philosophy and natural philosophy as it was actually being practised emerged for various reasons. Partially – and this is especially the case in England – it emerged because Cartesianism had overtaken scholastic Aristotelianism as the chief 'systematic' bête noire to be refuted.[94] But more significantly, it also emerged because there had been a genuine anti-scholastic movement,

90 See e.g. Buchwald and Feingold, op. cit. (7), pp. 9–10. Shapiro, op. cit. (12), is also of great importance on this score.

91 The key work being Schmitt, op. cit. (2).

92 For the fullest overview of anti-Aristotelianism see now Craig Martin, *Subverting Aristotle: Religion, History & Philosophy in Early Modern Science*, Baltimore: Johns Hopkins University Press, 2014; also Levitin, op. cit. (31), Chapters 4 and 5.

93 Isaac Newton, *Lectiones opticae*, in *The Optical Papers of Isaac Newton*, ed. A.E. Shapiro, vol. 1, Cambridge: Cambridge University Press, 1984, pp. 81–83.

94 The key overall study of the reception of Cartesianism in England remains Arrigo Pacchi, *Cartesio in Inghilterra: Da More a Boyle*, Rome and Bari: Editori Laterza, 1973. For some recent findings on early English anti-Cartesianism see Dmitri Levitin, 'Rethinking English physico-theology: Samuel Parker's *Tentamina de Deo*', *Early Science and Medicine* (2014) 19, pp. 28–75.

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which, crucially, had been institutionalized in the universities. The heroes of that story are neither Newton, who was a second-generation inheritor of this shift, nor Bacon, who for all his anti-Aristotelianism never demonstrated that a rival system or set of results was available. The real heroes of such a story may be the still rather understudied and underappreciated figures like Ralph Bathurst or Nathaniel Highmore: English physicians and naturalists of the 1650s who absorbed the virulent anti-Aristotelianism of Continental natural philosophers such as Sébastien Basson and Pierre Gassendi. They used it not to serve a destructive radicalism but to continue to promote the actual practice of natural philosophy within the learned institutions: the universities and the College of Physicians.[95] It was they who created the institutionalized intellectual culture in which Newton only had to develop a superficial familiarity with scholastic philosophy, and it was they and their colleagues who were the driving force behind the other institution which facilitated the practice of (experimental) natural philosophy, and of which Newton would eventually become president: the Royal Society of London.

95 For the importance of 1650s Oxford see esp. Mordechai Feingold, 'The origins of the Royal Society revisited', in M. Pelling and S. Mandelbrote (eds.), *The Practice of Reform in Health, Medicine and Science, 1500–2000*, Aldershot: Ashgate, 2005, pp. 167–183. For Bathurst, Highmore, their scientific practice and their intellectual debts, the key study remains Robert G. Frank, *Harvey and the Oxford Physiologists: A Study of Scientific Ideas* (Berkeley, CA: Berkeley University Press 1980), supplemented on Highmore in Levitin, op. cit. (31), Chapter 4.

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