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The Leibniz-Clarke Correspondence as a Case Study for the Historiography of Physics

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Abstract:

This paper examines an important episode in the history of early modern physics – the Leibniz-Clarke correspondence of 1715-16, an exchange that occurred at the intersection of physics, metaphysics and theology – before turning to questions of interpretation in the historiography of physics. Samuel Clarke, a disciple of Isaac Newton, engaged in a dispute over Newton's commitment to absolute space and absolute time with Gottfried Wilhelm Leibniz, who criticized Newton's views and advanced a rival account. I clarify the positions at stake in the Leibniz-Clarke correspondence, define a variety of terms – absolute space, absolute time, substantivalism, and relationalism – endogenous to the exchange, and reconstruct key elements in the philosophical dimension of the dispute. I then use the Leibniz-Clarke exchange as a springboard from which to examine interpretive considerations in the historiography of physics. I argue that the history of physics can benefit from reassessing its historiographical commitments by borrowing or appropriating some of the intellectual resources used by philosophers working in the history of philosophy. This historiographical reassessment, I contend, will not only shed new light on the Leibniz-Clarke exchange but may also reinvigorate the history of physics.

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Introduction

Once upon a time, there was a wizard that could make objects vanish. But not merely disappear; he had the power to make objects cease to exist. He would utter his spell, and – presto – his table blinked out of existence. Another incantation and his comfortable armchair was no more. One day, he got a bit drunk and began to use his non-existence spell on everything he saw. He applied his spell to his dog, his house, and the moon. More objects on Earth and beyond began to blink out of existence at an astonishing rate. No more Eiffel Tower. So long, Jupiter. Goodbye, Andromeda Galaxy. Eventually, everything vanished,

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including the wizard himself. Had anything endured this attack? What was left after everything that previously existed was extinguished?

One curious answer is that something unique, something that has a special kind of being, was spared the onslaught: space and time itself. Even if the contents were to cease to exist, that which contained them – space and time, the “container” of the contents of the universe – would still be. This, I imagine, is the answer that Isaac Newton, the celebrated 17th century English physicist and mathematician in whose work (the traditional story goes) the Copernican revolution found its conclusion, would give, if he were to have entertained this fanciful thought experiment.

This paper begins by investigating Samuel Clarke’s defense of Newton’s answer, somewhat modified by various early 18th century intellectual forces – call it Newtonian substantivalism – and Gottfried Wilhelm Leibniz’s criticism of it in the Leibniz-Clarke correspondence of 1715-16, a debate that occurred at the intersection of physics, metaphysics and theology. I clarify the positions at stake in the Leibniz-Clarke correspondence, define a variety of terms – absolute space, absolute time, substantivalism (both Newtonian and Newton’s), and relationalism – endogenous to the exchange, and reconstruct key elements in the philosophical dimension of the dispute. I then use the Leibniz-Clarke exchange as a springboard from which to examine interpretive considerations in the historiography of physics. I argue that the history of physics can benefit from reassessing its historiographical commitments by borrowing or appropriating some of the intellectual resources used by philosophers working in the history of philosophy. This historiographical reassessment, I contend, will not only shed new light on the Leibniz-Clarke exchange, but also reinvigorate the history of physics.

The Leibniz-Clarke Dispute: The Background

Newton maintained and strongly advocated a view predicated on absolute space and absolute time. Call such a view the absolute conception (of space and time). Lee Smolin observes that in “the introduction to his great *Principia*, which was the culmination of the Copernican revolution, he could not have been more direct: ‘Absolute space, in its own nature, without relation to anything external, remains always singular and immovable’” (Smolin 1997, 215). Also in his “Scholium” at the beginning of the *Principia*, Newton provides a complimentary account of absolute time.

Absolute, true, and mathematical time, of itself, and from its own nature, flows equably without relation to anything external, and by another name is called duration: relative, apparent, and common time, is some sensible and external... measure of duration by the means of motion, which is commonly used instead of true time; such as an hour, a day, a month, a year. (Newton 1995, 13)

The terms “absolute” and “relative” acquired their currency in classical physics with Newton. As J. B. Kennedy explains, “[t]he word ‘absolute’ means ‘independent’ in the sense that a thing is absolute when it does not depend on other things, is free from interference and makes itself what it is” (Kennedy 2003, 109). The picture of space and time provided by the absolute conception is that the reality of space and time are not determined by things *in* or events that flow *through* them.

Newton’s commitment to the absolute conception of space and time led to him being interpreted by his contemporaries as a substantivalist about space and time. Substantivalism is the view that space and time are real substances that endure despite the existence (or nonexistence) of any objects in space and time. Substantivalism is controversial, metaphysically ambitious, and, like its sibling absolutism, seemingly exceeds the limits

allowed by Newton's commitment to empirical evidence² for which he was well known. There is some debate about the extent to which Newton can be said to have positively embraced substantivalism. As Lawrence Sklar has observed, "Newton was cautious of thinking of space as a 'substance.' Sometimes he suggested it be thought of, rather, as a property – in particular as a property of the Deity" (Sklar 2000, 426). Furthermore, Robert Rynasiewicz has noted that "Newton did not regard space and time as genuine substances (as are, paradigmatically, bodies and minds), but rather as real entities with their own manner of existence as necessitated by God's existence (more specifically, his omnipresence and eternity)" (Rynasiewicz 2011). Irrespective of any full-throated endorsement of substantivalism, however, is Newton's unambiguous rejection of a relationalist account of space and time.

Relationalism rejects both substantivalism and the absolute conception of space and time. More positively, relationalism is the view that "space and time are relative, dependent upon the relations among objects and events" (Seager 2000, 225). Defending relationalism while subjecting substantivalism and Newton's absolute conception of space and time to scathing criticism was Leibniz, the German polymath with whom Newton had already sparred over credit for the invention of the modern calculus. Leibniz developed his relationalist account of space and time in what is now referred to as the Leibniz-Clarke correspondence, where he denied that space and time existed as independent entities, distinct from bodies "in" them.³ For the relationalist, space and time are abstractions instantiated by the spatial and temporal relations of objects and events; "only the 'contents' exist, not the 'container'" (Macchia 2010, 123).

Samuel Clarke, a disciple of and mouthpiece for Newton, defended substantivalism and the absolute conception of space and time. Even if Newton himself did not go in for substantivalism, the close family resemblance between substantivalism and the absolute conception of space and time united the two in the minds of many of Newton's supporters and critics, including Clarke and Leibniz, respectively. As a result, Newtonian substantivalism emerged. As Sklar explains, "[a]ccording to a Newtonian substantivalist, ... even if there were no matter in the universe whatever, there would still be space with its standard three-dimensional Euclidean structure, and there would still be 'instants' of time which together form a temporal order. Finally, there would still be those ordered pairs of places in space and instants in time which constituted event locations – even if there were no events at all" (Sklar 1977, 161). And, for the Newtonian substantivalist, space and time are proper substances that, enjoying independent existence, serve as the ground or foundation for reality. Henceforth, despite the efforts made to conceptually uncouple substantivalism from absolute space and absolute time, I adopt the convention of conflating the concepts as did Clarke and Leibniz. So, future references to Newton concern not the historical Newton, who may have been reticent about substantivalism, but rather Clarke's Newton (and, concomitantly, Leibniz's Newton), who was not. I refer, then, to Newton's substantivalism, not Newtonian substantivalism.

The Leibniz-Clarke Correspondence: A Philosophical Exchange

In this section, I offer an account of philosophical dimensions of the Leibniz-Clarke exchange as they concern divergent accounts of space and time. The exchange, though, ranges

² I take it that Newton's famous bucket argument is meant to serve as evidence for the existence of absolute space, even though the "evidence" provided by the argument is generated abductively, by means of an inference to the best explanation. I remain agnostic about the conclusion Newton drew concerning his bucket argument in this paper.

³ For the purposes of this paper, I ignore Leibniz's "deeper" metaphysics developed in the *Monadology*.

beyond the rather narrow confines of a disagreement about substantivalism and relationalism, though both would be tested and scrutinized therein. As a whole, the correspondence concerns “issues such as God’s role in the universe, the notion of miracles, the cause of gravity, and space and time” (Bertoloni Meli 1999, 469). The exchange, which consists of ten letters, began in 1715 and ended in 1716 with Leibniz’s death; Leibniz and Clarke each produced five letters. I focus on the metaphysical arguments about space and time in Leibniz’s Third and Fifth Papers and Clarke’s Third and Fifth Replies, reconstructing the salient arguments.

In his Third Paper, Leibniz submits the following claim – call it the “primary doctrines” statement – which succinctly states the relationalist position.

I hold space to be something merely relative, as time is; that I hold it to be an order of coexistences, as time is an order of successions. For space denotes, in terms of possibility, an order of things which exist at the same time, considered as existing together; without enquiring into their manner of existing. And when many things are seen together, one perceives that order of things among themselves. (Alexander 1956, 25-26)

Section 4 of Clarke’s Third Reply is a direct rejoinder to Leibniz’s primary doctrines statement. Clarke claims in section 4 of his Third Reply that “space and time are quantities; which situation and order are not” (Alexander 1956, 32). Clarke criticizes both of the main doctrines offered by Leibniz; namely, that space is an order of coexistences and that time is an order of successions. In Leibniz’s account, however, space and time don’t have a kind of independent being over and above that of physical objects and events. Leibniz’s metaphysics, then, stands in direct opposition to Newton’s account, where space and time are absolute.

For Newton, space and time are physical entities that exist independently of other entities. On Newton’s substantivalist account, it would be meaningful to talk about space and time even if no matter existed, for, on Newton’s view, space and time endure regardless of regular objects and the changes they make. Newton’s account encourages the image of space as a container ready to have objects occupy it. According to the container model, “[o]bjects are ‘in’ space and events take place ‘in’ time” (Sklar 1977, 162). For Leibniz, however, space is just the order of relations that objects bear to each other. According to Leibnizian relationalism, “God creates space in and through creating bodies and arranging them spatially in relation to each other. And he creates time in and through creating events in temporal relations to each other” (Broad 1975, 57). There is, then, no actual space and time existing apart from and prior to things and events for Leibniz.

As already mentioned, Clarke claims that space and time are quantities. However, the substantivalist position is not adequately expressed in this claim, worded as it is. Strictly speaking, the substantivalist thinks of quantity as a property of space and time; in fact, Clarke himself does in his Fifth Reply where he refers to the “quantity of space and time”. In presenting the substantivalist position, I will refer to quantity as a property of those entities called space and time. That said, Clarke rejects Leibniz’s primary doctrines statement on the grounds that quantity must be a property of space and time; the quantifiability of space and time, independent of any regular objects whatsoever, constitutes for the substantivalist the underlying reality that grounds all possible relations among objects. Relations between objects and between events require a certain structure for their very intelligibility.⁴ Substantivalists claim that this structural account is absent in the relationalist’s story.

⁴ For the substantivalist, this structure serves as the condition for the possibility of what Leibniz calls situation and order.

Consider, for example, the underlying structure of the solubility of salt. A piece of salt is, “even if not dissolved, possessed of the ‘possibility’ of going into solution. It is, we say, soluble. But this solubility rests upon the piece of undissolved salt having an actual constitution out of ions” (Sklar 1992, 21). The substantialist charge is that the relationalist account cannot, in principle, make sense out of the ultimate structure of space and time itself, in much the same way that explanations that do without a dispositional account cannot be good explanations.⁵ Clarke thinks that since absolute space is “infinite in extent, Euclidean and three-dimensional in structure, and persists through time” (Sklar 1977, 162) unchanged, absolute space and time ground the very possibility of any relations whatsoever. These properties of space and time are what make space and time a “quantity” for Clarke; since substantialism is able to offer such a structural account, it is superior to relationalism.

Consider three objects – rock, paper, and scissors – that change their positions. At time slice 1, rock is one meter from paper, rock is two meters from scissors, and paper is three meters from scissors. At time slice 2, paper is one meter from scissors, paper is two meters from rock, and scissors are three meters from rock. Newton claims that the distances between the objects at any time slice are quantifiable in virtue of their occupying regions of the substance of space and time, where space and time contains within itself, irrespective of any regular physical objects occupying it, regions that have distance between each other. Substantialism, in offering a means by which to quantify the changes that rock, paper and scissors manifest in occupying new positions at different time slices, grounds change in “space and time as autonomous constituents of the world” (Sklar 1992, 23). The relationalist can provide no such ground, as the mere order of co-existences and order of successions do not have an autonomous and quantifiable nature.

So thinks Clarke. Leibniz has a different story to tell. Part of that story is told in section 54 of the Fifth Paper, where Leibniz claims that “order also has its quantity; there is in it that which goes before, and that which follows; there is distance and interval” (Alexander 1956, 75). In effect, Leibniz argues that relationalism, in fact, *does* provide an account of the ground by which possible relations among objects and among events are based. The structure for the intelligibility of these relations is found in the order of coexistences and the order of successions; these orders, though, are dependent upon objects and their motions – they are not themselves the “autonomous constituents” of the world that substantialism affirms. The relationalist, then, defines space and time according to the spatial and temporal relations that obtain between, say, rock, paper, and scissors at various different time slices; relations of coexistence and relations of succession – not absolute space and time – are the means by which events involving rock, paper, and scissors are quantified. And these relations, in fact, possess quantity; therefore, they are the ground to which Leibniz refers. Leibniz establishes the claim that order admits of quantity through an argument by analogy: since ratios and proportions in mathematics are relations that admit of quantity, then space and time, as a set of relations, must also, Leibniz argues, “have their quantity”.

Clarke, however, in section 54 of his Fifth Reply, attacks Leibniz’s argument. I consider two of the arguments offered by Clarke against Leibniz in the Fifth Reply. The first argument attacks Leibniz’s argument by analogy, suggesting that that which is claimed to be analogous about the two classes of things in the stated comparison – ratios and proportions on the one hand, and space and time on the other – is, in fact, a poor comparison. Clarke states in section 54 that “proportions are not quantities, but the proportions of quantities. If they were quantities, they would be the quantities of quantities, which is absurd” (Alexander 1956, 105).

The second argument Clarke advances against Leibniz in the Fifth Reply that I will examine requires a glance back at a previous argument put forward in the Third Reply. In the Fifth Reply, Clarke claims that the “ distance, interval, or quantity of time or space wherein

⁵ This example assumes dispositionalism.

one thing follows another is entirely a distinct thing from the situation or order: the situation or order may be the same when the quantity of time or space intervening is very different” (Alexander 1956, 105). Earlier, in section 4 of his Third Reply, Clarke provides a thought experiment to demonstrate this point. In the Third Reply, Clarke writes that “if time were nothing but the order of succession of created things, it would follow that if God had created the world millions of ages sooner than he did, yet it would not have been created all the sooner” (Alexander 1956, 32). The next premise – one that Clarke wants the reader to supply for himself – is that if God had created the world millions of ages sooner than he did, then it really would have been created earlier. Moreover, we would like a way in which we could, in principle, know if God had created the world millions of ages sooner than (we think) he did. Time cannot simply be an order of successions, then, for time as an order of successions does not have the explanatory capability to account for such a problem. The relationalist cannot know if God created the world millions of ages sooner than (we think) he did. But the substantivalist can, in principle, know. The upshot of this thought experiment is that relationalism is flawed and substantivalism is the accurate theory.

Leibniz’s relationalist counter-argument is that the God in Clarke’s thought experiment disobeys the Principle of Sufficient Reason. The Principle of Sufficient Reason, premised on the need for complete intelligibility of any and all facts and framed by Leibniz as both an epistemic and a metaphysical principle, states that nothing happens without a reason. In Clarke’s thought experiment, there is no possible reason for God to prefer a universe created millions of ages sooner than he did, in fact, create it. For Leibniz, God never makes a decision without a sufficient reason, so the very intelligibility of Clarke’s thought experiment is found wanting.

Smolin illustrates Leibniz’s application of the Principle of Sufficient Reason (and, relatedly, the Identity of Indiscernibles) by using an example about space instead of time. Consider, he writes, that

it is impossible to think of a reason why the universe might not have been created, in its entirety, two feet to the left. This being so, it makes no sense at all to talk about where the universe, as a whole, is. Moving the entire universe two feet to the left is not going to have any imaginable effect on our perceptions, or on the future behavior of things in the universe.

If it is not going to make any difference whether the universe is as it is, or two feet to the left, does it still make any sense to distinguish the two? (Smolin 1997, 216)

Leibniz answered no. This question, Smolin writes, is “exactly what separates the relational from the absolute view of space” (Smolin 1997, 216).

The Historiography of Physics and the History of Philosophy: A Modest Proposal

Usually, debates in the history of science have winners and losers. Some physicists have celebrated Leibniz as the winner in the debate about space and time, for it appears that many advances in twentieth century physics, from Poincaré to Einstein, vindicate or at least share an affinity with Leibniz. Both the superiority of Leibniz’s arguments (apart from his argument from analogy, which Clarke showed to be flawed) and the happy relationship Leibniz’s relationalism has to modern physics encourage many to consider Leibniz the victor. And yet, as physicist Brian Greene observes, after the Leibniz-Clarke exchange ended with Leibniz’s death, “[d]uring the next two hundred years, the arguments of Leibniz and others against assigning space an independent reality generated *hardly an echo* in the scientific community” (Greene 2004, 31. Emphasis mine.). Nevertheless, as Smolin notes, it is “hard to think of an

argument in the history of science that *echoes more loudly today* than Leibniz's dissent from Newton's physics" (Smolin 1997, 215. Emphasis mine.). How could arguments that for two centuries "generated hardly an echo" serve such a resoundingly important precedent in physics today? We find the answer in the history of physics by charting the path from Leibniz and Newton to Einstein's special theory of relativity. But just what that path should look like – and the extent to which the path is direct or circuitous, fallow or verdant – depends on the interpretive constraints built into the historiography of physics that one selects. And the historiography of physics largely relies on the historiography of science generally.

The historiography of science offers several approaches with which to interpret the salient events that led twentieth century physicists to ultimately abandon substantivalism. Approaches that favor "stories about the great discoveries that present them as steps in a cumulative process by which our understanding of the natural world has expanded" (Bowler and Morus 2005, 1- 2) have been largely out of favor, to put it mildly, since the publication to Thomas Kuhn's *The Structure of Scientific Revolutions* in 1962. In Kuhn's wake, various "constructivist" considerations strongly influenced scholarship in the history of science. Historian Jan Golinski defines "constructivism broadly as an approach that directed attention at the role of human beings as social actors in the making of scientific knowledge" (Golinski 2005, vii). Within the constructivist camp, the Sociology of Scientific Knowledge or SSK, developed in the 1970s and 1980s, arguably became the most dominant school of thought influencing the historiography of science in the 1980s and 1990s. SSK interprets the establishment of scientific knowledge from within social, political and economic circumstances, effectively reducing scientific knowledge claims to power or to some other nonevidential consideration. After the eruption of the "science wars" and the Sokal affair in the mid-to-late 1990s, constructivist perspectives appear to have waned. The time seems ripe for conceptualizing new interpretive approaches – or reconsidering heretofore neglected approaches – for the historiography of science.

One approach to reconsider, I submit, involves borrowing some of the intellectual resources used by philosophers working in the history of philosophy. Philosophers who work in this field are not typically trained as historians, though they share with historians an interest in accounting for the past, despite the divergence of their respective methodologies. It is uncommon for philosophers working in the history of philosophy (hereafter PHP), in accounting for philosophy's past, to endorse a "development-by-accumulation" view of the kind criticized by Kuhn. It is equally unlikely for PHP to adopt a constructivist approach, especially one informed by SSK that exhibits reductionist tendencies. As a result, PHP have not had to face the historiographical challenges that historians of science have faced.

To explain what PHP do, I refer to Don Garrett's essay "Philosophy and History in the History of Modern Philosophy" (See Garrett 2004, 44-73). Garrett presents four different aims that one might have in examining philosophy's past. Garrett draws a connection between the four aims and the various hermeneutic considerations associated with them whereby each aim corresponds to a possible interpretive approach that PHP may employ. The first aim is to "contextualize works of the past. That is, one may seek to determine the various circumstances – intellectual, material, personal, social, and political – under which they were produced and which helped to determine their character" (Garrett 2004, 57). This will include acquiring knowledge about not only the author's education, influences, concerns, aims, and motives for writing, but also about the disputed intellectual issues of the day and their perceived impact on the author. The second aim is to interpret works from philosophy's history. The goal here is to understand what the author meant, and will typically include "trying to specify the meanings of various questions asked and claims made in the work; how the author intended these questions and claims to be related; ... what unexpressed doctrines are implicit or presupposed in the work; why the author wrote as he or she did; and what the author intended the work as a whole to convey" (Garrett 2004, 58). The third aim is to "evaluate philosophical works of the past" (Ibid., 58). Finally, the fourth

aim is to apply works of the past. Garrett entertains a myriad of different ways in which this fourth aim can be satisfied. One may simply agree with the solution to a philosophical problem that a thinker from the past has proposed and come to endorse that same solution yourself. But one may also “apply a philosophical work of the past by borrowing, criticizing, adapting, or developing questions, problems, formulations, concepts, distinctions, vocabulary, premises, arguments, examples, methods, skills, habits of mind, insights, projects, approaches, perspectives, and frameworks” (Garrett 2004, 59). Garrett concludes his presentation of these four aims by remarking that they do not exhaust what one might do with past philosophical works.

Let’s evaluate these four aims for the possibilities they may hold for the history of science, with special attention to the historiography of physics. Instead of being the aims that PHP have in evaluating *philosophy’s* past, imagine they are proposals concerning what may be the aims historians have in evaluating *science’s* history. Historians of science already satisfy the first and second aims.⁶ That is, historians of science, to appropriate Garrett’s language, “contextualize works of the past” and “interpret works from science’s history”. However, while some historians of science meaningfully satisfy the fourth aim by “applying works of the past”, most do not.⁷ PHP can meaningfully satisfy Garrett’s fourth aim by consistently applying insights of sufficient magnitude from philosophy’s past in contemporary philosophical debates.⁸ There is, though, no corresponding characteristic for the history of science. While some contemporary philosophers may be, for example, Platonists, no historians of science are, say, geocentrists in the Ptolemaic tradition.

That leaves the third aim, modified for the history of science: to evaluate *scientific* works of the past. Garrett describes this third aim as one that “will most centrally involve assessing the truth of the claims made and the strength of the arguments offered, as well as assessing the value, importance, and clarity of the questions raised, the soundness of the approaches employed, and the adequacy of the answers or solutions proposed” (Garrett 2004, 58). While PHP routinely adopt interpretive approaches and pursue research programs that satisfy this third aim, historians of science typically do not.⁹ But just what the history of science could look like if it were to adopt this aim and use it to guide a new interpretive approach is, I contend, worth considering, and perhaps promising. Even if it cannot properly ascertain whether a scientific claim from the past is *true*¹⁰, the history of science could evaluate the strengths of past scientific arguments – the evidentiary considerations – for a claim, while also examining the adequacy of competing answers or rival solutions proposed. This approach may require the history of science to forge a stronger relationship with practicing scientists, especially with scientists interested in the history of their field (See Darrigol 2007, 33-34). This, in turn, could lead the history of science to pursue new interdisciplinary pursuits, perhaps leading it to rekindle its somewhat cold relationship with the history of philosophy. In collaboration with scientists and PHP, historians of science could generate new knowledge as they, in Garrett’s words, assess the value, importance and clarity of the questions raised by science’s history.

6 In fact, to a large extent, so much of the history of science simply is the satisfaction of the first and second aims.

7 One exception is the journal *Studies in History and Philosophy of Science: Part B: Studies in History and Philosophy of Modern Physics*, which tends to feature articles that integrate the history of science and the philosophy of science. See also *The Past, Present, and Future of Integrated History and Philosophy of Science*, edited by Emily Herring et al.

8 Historically-minded physicists and philosophers of physics do this, too, with respect to the history of physics. See, in particular, the work of Julian Barbour, Harvey Brown, Don Howard, Oliver Pooley, Simon Saunders, Jos Uffink, and David Wallace.

9 Exceptions in the history of physics include the work of Alexander Blum, Olivier Darrigol, Silvan S. Schweber, Michael Nauenberg and other “internalist” historians of science.

10 Arguments against scientific realism abound. One influential account is found in Van Fraassen 1980.

To better anchor my proposal for reconsidering interpretive approaches in the historiography of science, I draw attention to philosopher Gary Hatfield's 1990 essay "Metaphysics and the new science" (hereafter MNS), which appeared in the edited volume *Reappraisals of the Scientific Revolution*. I contend that Hatfield's essay provides insights for how the historiography of physics may develop in the future, including considerations the application of which may further illuminate several episodes in the history of science, along with the Leibniz-Clarke exchange. While my applications of Hatfield's observations in this essay are limited, I encourage the more intrepid to develop them further.

In MNS, Hatfield reminds his reader that "in the sixteenth and seventeenth centuries, ... metaphysics was widely held to be a legitimate member of the sciences, if not the most basic science. Indeed, it was a science of presuppositions, or of 'first principles,' [the aim of which] was to argue for, or at least explicitly to portray, fundamental or basic... concepts" (Hatfield 1990, 94-95). As such, science and philosophy were intertwined in ways that professionals in these fields today would find disorienting. Despite the interconnectedness of science and philosophy in the early modern period, though, some boundaries were nevertheless maintained. As Hatfield observes, "Huygens and Newton would count as *mathematical scientists*. Leibniz would figure as a *metaphysician*, who posited a sharp boundary between metaphysics and physics but regularly argued across that border" (Hatfield 1990, 144. Emphasis not mine.). Hatfield's characterizations of these fields in MNS build on our already existing understandings of them and support a blunt assessment offered by historian John Henry: that "in the exchange of philosophical letters between Leibniz and Samuel Clarke..., the correspondence revealed two irreconcilable world-views" (Henry 2008, 80).

But how should we endeavor to understand the irreconcilability of these worldviews? Hatfield's answer in MNS is that we should "use the wheel of history to best advantage" (Hatfield 1990, 147). Hatfield's elaboration, consistent with the outlook employed by PHP, is a rousing salvo in defense of a reinvigorated research program for the history of science.

Contemporary historians of science are often leery of engaging the history of science philosophically, perhaps fearing that their historical interpretations will thereby be tainted. And so they might. But this danger does not justify a blanket supposition that the interpretation of history is inevitably prejudiced by philosophical aims and that it is impossible for the philosophically minded to learn from past texts. Moreover, interpretation can be undermined by insufficient philosophy.

[T]o examine metaphysics as it was historically conceived is to examine it as argument: as something put forward with conviction, in order to evoke conviction. Such an approach cannot be satisfied with the charting of influence; it requires seeing how a text hangs together and develops its force. Extended beyond metaphysical texts, it seeks to be sensitive to the distinctive styles of argument that philosophers and scientists have employed, whether metaphysical or not. (Hatfield 1990, 147-148)

Hatfield's statement, I contend, aptly coheres with Garrett's modified third aim. That is, in order to evaluate scientific works of the past, we must examine them as arguments that make claims and demand consideration.

In MNS, Hatfield warns against the exclusive use of hermeneutic tendencies in the history of science that leave little or no interpretive space to see controversies in early modern science as living debates that we can learn from and about which we are asked to have a view.

If we overlook the arguments and styles of argumentation that these authors chose to employ in their texts, we risk failing to appreciate the achievements embodied in their

works, and so failing to learn from these works as we might. For, beyond their obvious uses as historical documents, these texts stand as instances and models of argumentation, in which case they must surely be understood as arguments, if they are to be understood at all (whether or not they are emulated). To learn from such texts, we must engage them. (Hatfield 1990, 148)

Nevertheless, Hatfield readily acknowledges that historians of science satisfy what I've characterized as Garrett's first and second modified aims. He claims that he does

not wish to deny that intellectual biography, the charting of influence, and the excavation of presuppositions are useful and important for understanding philosophical and scientific texts. Nor do I claim that the rise of modern science took place independently of, or despite, [for example] Neoplatonic mysticism, hermeticism, and other "nonscientific" influences... Understanding such actual or possible interests can and does aid in the understanding of the texts of our authors at various points. But there is a danger in relying too heavily on such an approach... [it is] the danger of dissolving text and author into a set of background influences. (Hatfield 1990, 148)

The inherent risk in the dominance of constructivist approaches in the history of science is that theories and theorists, science and scientists – texts and authors, in Hatfield's language – fade away into nothing (or little) more than a "set of background influences". Fusing Hatfield's observations and proposals for the history of science from MNS to Garrett's modified third aim yields a needed remedy that both guards against overreliance on constructivist approaches in the historiography of science and charts a new path for what the historiography of science can become.

Conclusion

In the Introduction, I stated that in borrowing or appropriating some of the intellectual resources used by philosophers working in the history of philosophy, the history of science would not only shed new light on the Leibniz-Clarke exchange, but also, perhaps, reinvigorate the history of physics. But what this new light might reveal about the Leibniz-Clarke exchange remains to be seen. Knowledge already generated about the Leibniz-Clarke dispute is, like any topic in science's history, a poor predictor of knowledge yet to be produced. While details about the future engagements with the Leibniz-Clarke dispute are presently unknown, an assessment of the engine that (I contend) should drive future engagements with the history of physics is possible.

One way to operate this engine involves uniting or fusing the history of science with the philosophy of science – a new amalgamation that some call integrated History and Philosophy of Science or iHPS. This novel compound is one form that the borrowing or appropriation of intellectual resources has recently taken. As the editors of the 2019 volume *The Past, Present and Future of Integrated History and Philosophy of Science* make clear in their Introduction, "iHPS has been relatively recently established as an institutionalized field of research" (Herring et al. 2019, 6). Interestingly, in the same sentence, the editors acknowledge that "one could trace the origins of the integration of historical and philosophical considerations about the study of nature as far back as Aristotle" (Herring et al. 2019, 6). Using Aristotle as inspiration for what iHPS can become seems appropriate because the very novelty of iHPS breeds methodological uncertainty. Aristotle's happy catholicity allows for the norms of historical and philosophical considerations to coexist without tearing what could be jointly produced between them, namely iHPS, asunder. My earlier statement about borrowing or appropriating intellectual resources functions best, I

think, as a promissory note; the proverbial phrase “only time will tell” seems to best capture its predictive potential, even with hope for a rapprochement brokered in the spirit of Aristotelian unity. I see Hatfield’s argument as encouraging this brokerage. In order to make good on Hatfield’s exhortation to “engage the history of science philosophically”, one more brief look at (the history of) the historiography of physics is appropriate.

Hatfield’s MNS appeared in *Reappraisals of the Scientific Revolution* roughly nine years after the publication of Steven Shapin’s 1981 essay “Of Gods and Kings: Natural Philosophy and Politics in the Leibniz-Clarke Disputes”. In that essay’s opening paragraph, Shapin observed that, regarding the Leibniz-Clarke exchange, recent

intense concern with these controversies means that we can no longer reasonably expect the discovery of significant new facts. The emphasis has shifted to interpreting what is already known about these episodes and the setting in which they occurred. This is a highly desirable state of affairs, for the Newton-Leibniz controversies crystallize a number of issues of general significance. What is the proper interpretation of the relations between natural philosophy, mathematics, metaphysics, theology, and the social and political setting in which these matters were disputed? (Shapin 1981, 187)

Perhaps Shapin overstated his case in claiming that the discovery of significant new facts in the Leibniz-Clarke exchange is not reasonable to expect. Engaging the history of science philosophically – an interpretive approach that Shapin, a leading figure largely responsible for promoting SSK in the history of science, tends to eschew¹¹ – would generate new philosophical knowledge, and, therefore, significant new facts, relevant to the Leibniz-Clarke exchange. In the first half of this paper, I have offered a very modest contribution to the effort of producing a relevant philosophical exegesis of the Leibniz-Clarke dispute for the history of physics. But more voices must be heard.¹²

Since the publications of Shapin’s 1981 essay and his 1985 book, *Leviathan and the Air-Pump*, co-authored with Simon Schaffer, interpretive considerations of a distinctly constructivist bent, endorsed by Shapin, have shaped the field. Shapin’s question, about the “proper interpretation of the relations” between science, mathematics, metaphysics, theology, and the social and political context in which the Leibniz-Clarke exchange occurred, finds an answer in the history of science’s satisfaction of Garrett’s first two modified aims. However, the disregard for Garrett’s third modified aim, shown by Shapin and others, has led to an imbalance in the history of science. For those interested in considering a new direction, the one charted by Hatfield is a promising one for the history of physics.

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¹¹ See especially Shapin’s remarks about his methodological commitments in the section “Some Historiographical Issues” in the Introduction to his *The Scientific Revolution*, pages 8-11.

¹² There are, of course, voices already. In addition to Sklar 1977, Sklar 1985, and Sklar 1992, see Earman 1989, Rundle 2009, Dainton 2010 and Huggett 2010. However, while these works, to varying degrees, acknowledge the role of historical exegesis, they are heavily weighted in favor of philosophical analysis. This is no criticism; they are all contributions to the philosophy of physics. What seems to be absent is a significant contribution that marries both the history of physics and the philosophy of physics in a balanced way.

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