
Hobbes's Theory of Space

Douglas Jesseph

Philosophy in the seventeenth century is often, and with reason, characterized as a collection of grand systems devoted to an all-encompassing account of the world and its workings. Yet even in an era that featured such systematic thinkers as Descartes, Spinoza, and Leibniz, Hobbes is noteworthy for his “big picture” approach to philosophy. His tripartite *Elements of Philosophy* features the treatises *De Corpore*, *De Homine*, and *De Cive*, which were presented to the public as an exposition of all the philosophy worth knowing. Indeed, one might suspect that by entitling his system *Elements of Philosophy*, Hobbes was attempting to do for philosophy what Euclid's *Elements* had done for geometry. The structure of the three works in Hobbes's *Elements* reflects his conception of the structure of knowledge: beginning with a treatise on the nature of body, Hobbes next proceeded to examine the nature of humans (i.e., animated, rational bodies), and thence to a discourse on the nature of the commonwealth (the artificial body bound together by human covenants). In consequence, Hobbes's *De Corpore*—a dissertation on the nature of body—occupies the foundational place in his system, and its foundational status is due to the fact that Hobbes held to a strict materialism in which only body is real, so that all else must be accounted for in terms of the action of bodies.¹

A system founded on the nature of material bodies must also require that the concept of space be given central importance. My purpose here is to examine Hobbes's account of the nature of space, with the intent of showing how his theory

D. Jesseph (✉)
Department of Philosophy, University of South Florida,
4202 E. Fowler Avenue, Tampa, FL 33620, USA
e-mail: djesseph@usf.edu

¹ As it happens, these three parts of the Hobbesian system were published out of order: *De Cive* first appeared in 1642, *De Corpore* in 1655, and *De Homine* in 1658.

of space fits together with his fundamental ontology, his philosophy of science, and his idiosyncratic approach to the foundations of geometry. Toward that end, I will start with an overview of Hobbes's conception of space and time; I then take up some traditional philosophical questions concerning the nature of space and contrast Hobbes's approach with others, notably Descartes and Thomas White. I will conclude by briefly considering how Hobbes's theory of space influences his account of geometry.

1 Hobbes on Space and Time

Hobbes defined philosophy as “such Knowledge of Effects, or Appearances, as we acquire by true Ratiocination from the knowledge we have first of their Causes or Generation; And again, of such Causes or Generations as may be from knowledge first of their Effects” (*DCo* 1.1.1). Reasoning from effects to their (possible) causes is what he termed “analysis,” while that which moves from causes to effects is “synthesis;” both are essential to philosophy, and they both require an understanding of the concept of causation.² Further, Hobbes held that motion was the only cause of all things (*DCo* 1.6.5), so that the concept of motion is implicated whole of Hobbes's philosophy. In fact, there is no obvious demarcation between first philosophy and natural philosophy in Hobbes's system because the fundamental notions in his first philosophy include seemingly physical concepts such as body and motion.

Hobbes held that the foundations of natural philosophy are to be found by starting with the thought experiment (as we would now term it) of supposing the annihilation of the entire world, with the exception of one individual.³ According to Hobbes, the solitary thinker who survived the otherwise complete annihilation of the world would retain “Ideas of the World, and of all such Bodies as he had, before their annihilation, seen with his eyes, or perceived by any other Sense; that is to say, the memory and Imagination of Magnitudes, Motions, Sounds, Colours & c. as also of their order & parts” (*DCo* 2.7.1). On the basis of this collection of “phantasms” retained from past experience, such a thinker would be supplied with the concept of space, because any recalled phantasm would still contain information about the “order and parts” of the phenomenal world. Recollecting such phantasms and taking these merely to be representations of objects external to his perceiving mind, our thinker will “have presently a Conception of that we call *Space*, an Imaginary

² The literature on Hobbes and the concepts of analysis/synthesis is vast. For a general overview see Engfer (1982) and Hintikka and Remes (1974). Watkins (1965, Chaps. 3 and 4) places Hobbes's account in the tradition of the Italian “School of Padua,” while Prins (1990) argues against such a connection. See also Hanson (1990) and Talaska (1988) for further accounts of Hobbes on analysis and synthesis.

³ On the “annihilation experiment” in Hobbes and its background in earlier philosophical traditions, see Leijenhorst (2002, pp. 109–111).

Space indeed, because a meere Phantasme, yet that very thing which all men call so" (*DCo* 2.7.2). Hobbes then took this thought experiment to show that that space is to be properly defined as "*the Phantasme of a Thing existing without the mind simply*, that is to say, that Phantasme, in which we consider no other Accident, but onely that it appears without us" (*DCo* 2.7.2).

This definition has been the source of some considerable confusion and debate among Hobbes's interpreters. It appears to take space to be a "phantasm," or a purely subjective appearance, rather than an objective, observer-independent framework in which objects and events are located. Seth Ward, one of the earliest critics of Hobbes's program for natural philosophy, complained that the definition was "obscure and false" and "seems to be something only an insane person would say" (Ward 1656, pp. 69, 73) because it confuses a subjective experience or phantasm with the objective location of bodies that constitutes space. Some later commentators have seen in Hobbes's definition of space an anticipation of Kant's theory of space as a form of external intuition, derived from a "phenomenological reduction" of experience.⁴ However, Hobbes's reasons for adopting his account of space show that his doctrine lacks a significant connection to Kant's. Hobbes emphatically did not take space as some kind of transcendental principle that conditions our perceptions of external objects, but rather as the effect of bodies that interact with our perceptual system. Further, Hobbes took the concept of space to be an empirical in origin instead of an a priori form of perception that is presupposed in any experience. Finally, it is worth noting that Hobbes defined the key term "phantasm" in terms of the motion of material bodies: a phantasm is simply motion communicated from external bodies through the human sensory apparatus, where it elicits a counter-motion.⁵ In other words, rather than taking space as a basic concept in terms of which to define motion, Hobbes took motion as basic and defined space in terms of it.⁶

The definition we have been considering identifies what Hobbes termed "Imaginary Space," and if this were all he had to say on the matter he would in fact have been some kind of idealist for whom space is a subjective or mind-dependent

⁴ Herbert (1987, p. 701) declared that "Hobbes's account of space anticipates in many respects the Kantian phenomenology of space that will appear more than a century later," although the basis for this characterization is highly problematic. See Leijenhorst (2002, p. 107) for the difficulties involved in this interpretation.

⁵ Hobbes did not actually define the key term 'phantasm' until the fourth part of *De Corpore*. He first defined 'sense' as '*a Phantasme, made by the reaction and endeavor outwards in the Organ of Sense, caused by an Endeavour inwards from the Object, remaining for some time more or less*' (*DCo* 4.25.2); he then declared a phantasm to be an instantaneous instance of sense: "For a *Phantasme* is the act of Sense, and differs no otherwise from Sense then *fieri* (that is, Being a doing) differs from *Factum esse*, (that is, Being done;) which difference, in things that are done in an Instant, is none at all; and a *Phantasme* is made in an Instant" (*DCo* 4.25.3).

⁶ Brandt (Brandt 1928, p. 253) finds this problematic because "everything is to be motion, hence the idea of magnitude is also 'in reality' motion—but motion cannot be conceived without space and magnitude."

ordering that individuals assign to items of their experience.⁷ However, the Hobbesian doctrine of space does not end with the definition of imaginary space. A key point to consider here is that the main reason for calling something *imaginary* is to contrast an imaginary thing with its *real* or objective counterpart. In Hobbes's treatment of space, this contrast results in the concept of *real space*, which has an objective system of orderings that locates objects in a way independent of the perceptions of any particular mind.

Hobbes announced that "The Extension of a Body, is the same thing with the MAGNITUDE of it, or that which some call *Real Space*. But this *Magnitude* does not depend upon our Cogitation, as Imaginary Space doth; for this is an Effect of our Imagination, but *Magnitude* is the Cause of it; this is an Accident of Mind, that of a Body existing out of the Mind" (*DCo* 2.8.4). This passage clearly intends to distinguish between imaginary and real space: imaginary space is the subjective ordering of objects that arises from external bodies' interaction with the perceiver's sensory system; in contrast, real space is the objective location of external bodies. Indeed, Hobbes's definition of the term 'body' as "*that which having no dependence upon our Thought is coincident or coextended with some part of Space*" (*DCo* 2.8.1) requires the objective ordering of things in real (i.e., not mind-dependent) space.

It is worth noting that when Hobbes defined imaginary space as a "phantasm," the term *phantasm* carries a good deal of spatial content with it. A phantasm, is "made by the Reaction and endeavor outwards in the Organ of Sense, caused by an Endeavour inwards from the Object" (*DCo* 4.25.2), so the very concept of a phantasm presupposes such spatial orientations such as 'inward' and 'outward'. I take this as a tolerably clear indication that imaginary space presupposes the existence of a real space in which objects and events are ordered.

The easiest way to illustrate the distinction between imaginary and real space is to consider the case of spatial orderings. In observing two glasses on a table, a perceiver might see the wine glass as located to the left of the water glass. But such an ordering is clearly subjective because it depends upon the relative positions of the observer and the two glasses. Thus, it makes sense to say that the wine glass is to the left of the water glass in the imaginary space determined by the phantasms of our perceiver. But this ordering does not hold in an absolute or objective sense because there are plenty of reference frames in which perceivers would not see such an ordering. There is, nevertheless, an objective fact of the matter about the relative positions of the two glasses, and this position in real space (together with the spatial location of the perceiver) is what causes the ordering in imaginary space.

Hobbes drew a more informative and explicit distinction between imaginary and real space in his long manuscript treatise critiquing Thomas White's 1643 work *De Mundo Dialogi Tres*. White's dialogues were a response to Galileo's case for Copernicanism as set forth in the *Dialogue on the Two Chief World Systems*, and

⁷ See Leijenhorst (2002, pp. 105–122) for a discussion of Hobbes's treatment of imaginary space and its background in medieval discussions of the ontology of space. Grant (1969) is a useful summary of medieval accounts of imaginary space.

Hobbes undertook the defense of Galileo. In his critique of White, Hobbes defined imaginary space as “the image or phantasm of a body,” concluding that “the existence of this [space] does not depend on the existence of body but on the existence of the imaginative faculty.”⁸ However, “it is impossible that we suppose there to be some body without at the same time thinking it to be endowed with its own dimensions or spaces. Therefore this space, which can be called real, is inherent in a body, as an accident in its subject, and would surely exist even if there were nothing that could imagine it.”⁹

Imaginary space is therefore not an independent construct of the mind but rather an effect of the action of external bodies on the senses. To better understand this point, we should recall that Hobbes's materialistic ontology identifies body as the only substance. Because space cannot be identified with any particular body (or collection of bodies), it must be an “accident” of body. Hobbes defined an accident of body as “*the Manner by which any body is conceived,*” or also as “*that faculty of any Body by which it works in us a Conception of it self*” (*DCo* 2.8.2). There are, in fact, two definitions of the term ‘accident’ at work here. The first proceeds “subjectively” by defining an accident in terms of how it is conceived; the second proceeds “objectively” by defining an accident as the means whereby a body generates a phantasm in a perceiving mind. This distinction allows Hobbes to define his two notions of the accident that is space: imaginary space is the subjective (or, in Hobbes's terms, “fictive”) location of a body as it appears to a perceiver. Hobbes held, however, that this “feigned Extension” of a body in imaginary space is distinct from its *magnitude* or what he called its “true Extension” (*DCo* 2.8.5). The Hobbesian concept of real space thus characterizes it as the magnitude of a body, while imaginary space is the “phantasm” produced by external bodies acting upon the senses; or, as one commentator has put it, “the relation between *spatium reale* to *spatium imaginarium* exemplifies the cause-effect relation existing between our ideas and external things” (Leijenhorst 2002, p. 107).

Hobbes's account of time has important similarities to his theory of space, with one very important difference. Time is defined in *De Corpore* as “*the Phantasme of Before and After in Motion*” (*DCo* 2.7.3); this account is clearly analogous to his definition of imaginary space as “*the Phantasme of a Thing existing without the Mind simply*” (*DCo* 2.7.2). Time is therefore defined as a mental representation of motion rather than a self-subsistent entity that exists independently of any perceiving minds or moving bodies. However, where he had distinguished between imaginary and real space, Hobbes did not suppose a “real time” existing independently of the activity of minds that keep track of passage. He reasoned:

⁸ “dicemus *spatium esse imaginem corporis, quatenus corporis* . . . Manifestum hinc est existentiam spatii dependere non ab existentia corporis sed ab existentia imaginativae facultatis” (*CDM*, 3.1, p. 117).

⁹ “Neque possibile est ut corpus aliquot desse existimemus, quin simul putemus ipsum praeditum esse dimensionibus, sive spatiis suis. Hoc spatium igitur quod appellari potest reale inhaerens corpori, ut accidens in subiecto suo, existeret sane, et si nihil esset quod ipsum imaginari possit,” (*CDM*, 3.2, p. 117).

For seeing all men confess a Yeare to be Time, and yet do not think a Year to be the Accident of Affection of any Body, they must needs confesse it to be, not in the things without Us, but only in the Thought of the Mind What then can Dayes, Monthes and Years be, but the Names of such Computations made in our Mind? *Time* therefore is a Phantasme, but a Phantasme of Motion, for if we would know by what Moments Time passes away, we make use of some Motion or other, as of the Sun, of a Clock, or the sand in an Hourglasse. (*DCo* 2.7.3)

Notwithstanding his steadfast opposition to the great majority of Aristotelian doctrines, Hobbes took this theory of time to be consistent with Aristotle's definition. The Aristotelian definition of time (*Physics* IV, 11 220^a 24–25) characterizes it as "the number of movement in respect of the before and after." Hobbes said of this definition that because "that Numbering is an act of the mind; and therefore it is all one to say, *Time is the Number of Motion according to Former and Later*; and *Time is a Phantasme of Motion Numbered*" (*DCo* 2.7.3).

In Hobbes's account of space and time, it turns out that time is an accident of motion, where space is an accident of extension or magnitude. The accident that is time is mind-dependent, however, because it requires a perceiver to compute or reckon its passage. In the contrasting case of extension, the accident that is space has an observer-dependent aspect (namely, imaginary space) and an objective aspect (real space). Hobbes declared that "MOTION and MAGNITUDE . . . are the two most common Accidents of Bodies," (*DCo* 3.15.1) and he also announced that "The Extension of a Body is the same thing with the MAGNITUDE of it," (*DCo* 2.8.4). It follows that the two most fundamental properties of body are motion and extension. Space and time are consequences of these two basic accidents. Space derives from the accident of extension, with real space identified with a body's location, while imaginary space is the phantasm of its position in some perceiver's mind. Time, in contrast, is identified with the measure of a body's motion; and because all measurement presupposes a measuring mind, time is inevitably an *ens rationis*.

There are some oddities in this metaphysics of space and time that are worth considering. At the level of fundamental ontology, Hobbes took material bodies as absolutely basic. As we have seen, every body possesses two primary and inalienable accidents, namely magnitude and motion. From these, Hobbes then proceeded to define the concepts of space, place, and time. However, this all seems rather backward. One would normally expect space and time to be taken as primitives, with body and motion defined in the obvious way: body is that which occupies a region of space, and motion is translation of a body through a spatial distance in a given time. Hobbes did not take this route, evidently because he regarded the concepts of body and motion as so perspicuous as to be explanatorily prior to those of space and time. A second oddity in Hobbes's approach is that he seems to have fallen into the trap of trying to define everything: after he had defined space and time in terms of body and motion, he then defined body in terms of place or space (*DCo* 2.8.1) and motion in terms of space and time (*DCo* 2.8.10). The result of this typically Hobbesian definition-mania is a first philosophy that contains a set of seemingly circular definitions.

2 The Limits of Hobbes's Doctrine of Space and Time

Although Hobbes was not shy about claiming demonstrative certainty for a wide variety of physical, political, and philosophical principles, there are a number of fundamental questions concerning the nature of space (and, to a lesser extent, time) that he took to be either unanswerable, or (if answerable at all) only to be resolved empirically. Hobbes held that two a priori demonstrable principles governed all bodies in motion: first that a body could never initiate or extinguish its motion, and second that the only way the state a body could be altered is through contact with another body.¹⁰ These comprise a very general framework within which natural-philosophical investigations can be undertaken.

Nevertheless Hobbes's epistemology also placed a number of traditional questions about the infinity and uniqueness of the world outside the scope of philosophical investigation. Hobbes held that the origin of all concepts "is that which we call SENSE; (For there is no conception in a mans mind, which hath not at first, totally, or by parts, been begotten upon the organs of Sense.) The rest are derived from that original" (*L* 1.1, p. 3). He further insisted that:

Whatsoever we imagine, is *Finite*. Therefore there is no Idea, or conception of any thing we call *Infinite*. No man can have in his mind and Image of infinite magnitude; nor conceive infinite swiftness, infinite time, or infinite force, or infinite power. When we say any thing is infinite, we signifie onely, that we are not able to conceive the ends, and bounds of the thing named; having no Conception of the thing, but of our own inability. (*L* 1.3, p. 12)

A consequence of these epistemological restrictions is the outright rejection of traditional philosophical investigations into the question whether the world is finite or infinite, or whether there might be multiple worlds.

Natural philosophers had long been concerned to determine whether the world is finite or infinite, or whether there could be worlds other than ours, and discussions of these topics are a feature of much ancient and medieval philosophy.¹¹ Hobbes, however, regarded all such speculation as pointless. Considering disputes over the finitude or infinitude of the world, he insisted that "when we make question whether the World be Finite or Infinite, we have nothing in our Minde answering to the name *World*; for whatsoever we Imagine, is therefore Finite" (*DCo* 2.7.12). Although any given imagined space must be finite, we can nevertheless always imagine it to be further extended. Consequently, there can be no determinate limit to the extent of imaginary space. On Hobbes's principles, to say that the world is infinite is merely to say that we cannot conceive it as bounded; but this does not

¹⁰ I term these two principles the "persistence principle" and the "action by contact" principle. Both are demonstrated (at least to Hobbes's satisfaction) in Part II, of *De Corpore*, Sections 8 and 9. The first is a version of the law of inertia that asserts "*Whatsoever is a Rest, will always be at Rest, unless there be some other Body besides it, which by endeavouring to get into its Place by motion, suffers it no longer to remain at Rest.*" (*DCo* 2.8.19). The second claims "There can be no Cause of Motion, except in a Body Contiguous, and Moved." (*DCo* 2.9.7). I discuss them at greater length in (Jesseph 2006).

¹¹ See Duhem (1985) for a further account of such speculations.

exclude the possibility that the universe is of finite extent yet too vast to be grasped by our limited cognitive capabilities. However, we could never have sufficient evidence to justify the claim that imaginary space is literally infinite, because there can be no “phantasm” of the infinite. Likewise, we cannot exclude the possibility that there are other worlds besides this one, although we can have no empirical evidence of the existence of such worlds. Questions of this sort are therefore unanswerable, at least philosophically.

Hobbes’s principles thus lead to a more modest natural-philosophical program than many of his contemporaries or predecessors, at least where questions about the finitude or uniqueness of the world are concerned. In commenting upon these issues, Hobbes remarked

And this is of it selfe so manifest, that I should not thinke it needed any explaining at all, but that I finde Space to be falsely defined by certaine Philosophers, who inferred from thence, One, that the world is Infinite; for taking *Space* to be the Extension of Bodies and thinking Extension may increase continually, he inferres that Bodies may be infinitely Extended; and Another from the same Definition concludes rashly, that it is impossible even to God himself to create more Worlds then one; for if another World were to be created, he says, that seeing there is nothing without this world, and therefore (according to his Definition) no Space, that new world must be placed in nothing, but in nothing nothing can be placed, which he affirms onely, without shewing any reason for the same; whereas the contrary is the truth: for more cannot be put into a Place already filled, so much is Empty Space fitter then that which is Full for the receiving of new Bodies. (*DCo* 2.7.2)

This passage is directed at the reasoning of Descartes and Thomas White. Descartes’ error (in the *Principles of Philosophy*, Part II, article 21) was to conclude that the universe must be infinite in extent because we can imagine any supposed limit to the world to be surpassed. As he put the matter “Wherever we imagine those limits [of the world] to be, we can always not only imagine some indefinitely extended spaces beyond them, but also perceive that these are truly imaginable, that is to say real; and thus indefinitely extended corporeal substance is also contained in them” (Descartes 1964–1976, 8: 52). White’s error (in the third part of the first dialogue of his *De Mundo Dialogi Tres*) was to assume the principle that “what is situated in nothingness has no place,” from which he concluded that the world as a whole could not be placed, since there is no location apart from the universe in which it could be placed.¹²

In contrast to these mistaken arguments, Hobbes held that the concept of space (whether imaginary space or real space) can yield no answer to these questions. All our knowledge of the world is derived from the “phantasms” of sense experience, but none of these is infinite, nor can we have experience of an alternate world beyond the spatio-temporal bounds of this one. Therefore, no sense experience can decide the issue of whether the universe is finite or infinite, or whether there are other worlds besides this one. Furthermore, our spatial concepts cannot resolve such

¹² White remarks “quid clarius esse potest quam positam in nihilo rem locum nullum habere?” (White 1643, p. 28).

questions a priori; consequently, questions about the infinity and uniqueness of the world can be dismissed as seventeenth-century pseudo-problems.

Hobbes returned to these themes in Part IV of *De Corpore*, again emphasizing that questions about the magnitude, duration, and uniqueness of the world must be “inscrutable” because no experience can decide the issue. As he framed the issue: “Whatsoever we know that are Men, we learn it from our Phantasmes, and of *Infinite* (whether Magnitude or Time) there is no Phantasme at all; so that it is impossible either for a man, or any other creature to have any conception of *Infinite*.” Moreover, “whether we suppose the World to be Finite, or infinite, no absurdity will Follow. For the same things which now appear, might appear, whether the Creator had pleased it should be Finite or Infinite” (*DCo* 4.26.1). Neither experience nor a priori reasoning from the concepts can settle the issue, therefore such questions “are not to be determined by Philosophers, but by those that are lawfully authorized to order the Worship of God” (*DCo* 4.26.1).

Hobbes's dismissal of questions about the infinity or uniqueness of the world contrasts with his handling of debates over the existence of a vacuum. Aristotle had offered several a priori arguments against the possibility of a vacuum in the *Physics* (I 7), and the question of the void was a standard topic in medieval treatments of natural philosophy.¹³ The issue remained the subject of philosophical dispute well into the seventeenth century, with Descartes declaring that it “is a contradiction to suppose there is such a thing as a vacuum, i.e. that in which there is nothing whatever,” in the second part of his *Principles of Philosophy*. In elucidating this doctrine Descartes argued that, if we suppose a vessel to contain a literal vacuum, then “when there is nothing between two bodies, they must necessarily touch one another,” so that the sides of the vessel containing the supposed vacuum must collapse upon each other (Descartes 1964–1976, 8: 48, 50). Thomas White accepted the cogency of this argument, offering that “If a there were a vacuum, there would be a place without body, that is, a concave body without anything to fill the cavity. So the sides of this concave body will close up because there is no *ens* between them. But if the sides are closed up, this shuts out the vacuum.”¹⁴

Hobbes regarded such a priori arguments against the vacuum as comical misapplications of philosophical method. Both Descartes and White mistake the issue by assuming that a void must be a spatial region containing literally nothing, rather than nothing *other than space itself*. He remarked:

And this is so easie to be understood, that I should wonder at some men, who being otherwise skillful enough in Philosophy, are of a different opinion, but that I finde that most of those that affect Metaphysical subtilties, wander from Truth, as if they were led out of the way by an *Ignis Fatuus*. For can any man that has his natural Senses, think that two Bodies must therefore necessarily Touch one another, because no other Body is between them? Or

¹³ See Duhem (1985, part IV) for an account of medieval disputes regarding the vacuum.

¹⁴ “Si enim vacuum est locus sine corpore, hoc est, corpus concauum, sine aliquot cauitatem implead, none vides concauitatem quanta esse sine tertiâ mediante. Vides ergo ex ipsa notione vacui conjuncta esse latera, etsi conjuncta sint, iam nullum reliquum esse vacuum” (White 1643, pp. 30–1).

that there can be no *Vacuum*, because *Vacuum* is nothing, or as they call it, *Non Ens?* Which is as childish, as if one should reason thus; No man can Fast, because to Fast is to eat Nothing; but Nothing cannot be eaten. (*DCo* 2.7.9)

In Hobbes's view, the question of whether there is a vacuum is an empirical one, to be decided on the basis of experiment rather than a priori reasoning. Unlike the questions of the finitude or uniqueness of the world (where he held that experience cannot settle the issue) Hobbes argued that the experimental evidence convincingly refuted the hypothesis of a vacuum.

Hobbes proposed to "instance in onely one experiment, a common one, but (I think) unanswerable" to refute the hypothesis of the vacuum (*DCo* 4.26.2). This experiment involves a vessel "such as Gardiners use to water their Gardens withal," having small holes in the bottom and a larger opening at the top. When the vessel is filled with water and the top stopped shut, water does not flow through the holes; but when the top is opened, water does flow. Hobbes concluded that "the Water cannot by its natural endeavor to descend, drive down the air below," because there is no vacuum beneath it. The experiment therefore offers convincing evidence "that all Space is full; for without this, the natural motion of the water . . . downwards, would not be hindered" (*DCo* 4.26.21).

Those who accepted the reality of the vacuum based their opinion on what Hobbes termed "many specious arguments and experiments" that he took it upon himself to refute. He argued that all such evidence for the existence of a vacuum is either inconclusive or inconsistent with other a priori principles governing the motion of bodies. In order to clarify Hobbes's conception of space and his scientific methodology, it is worthwhile to consider two of these: first an a priori argument drawn from Lucretius concerning the necessity of vacuum to permit motion, and second an argument drawn from experiment of the "Torricellian tube."

The Lucretian argument that a vacuum is necessary for there to be motion reasons that "the office and property of Bodies is to withstand and hinder motion," so that in a world with no vacuum "motion would everywhere be hindered, so, as to have no beginning anywhere, & consequently there would be no motion at all" (*DCo* 4.26.3). Hobbes granted that "in whatsoever is full, and at rest in all its parts, it is not possible motion should have a beginning," (*DCo* 4.26.3), but this is because no body (or collection of bodies) can initiate its own motion. This principle Hobbes took to be demonstrably certain (and he credited himself with having demonstrated it in *DCo* 2.9.7). But, he argued, it is irrelevant to the case of the vacuum. At most, the Lucretian argument could show that "motion was either coeternal, or is of the same duration with that which is moved" (*DCo* 4.26.3), but it cannot rule out the possibility that the world is a plenum, albeit one containing many fluid bodies that offer no resistance to larger moving bodies. Thus, the argument yields no reason a priori in favor of the vacuum and against plenism.

The familiar Torricellian experiment involves inverting a tube filled with mercury and sealed at one end, placing the open end in a dish likewise filled with mercury and then inverting it. The mercury in the inverted tube descends, and the space at the top of the tube vacated by the mercury is characterized as a vacuum

(at least by proponents of vacuism). Hobbes claimed to “finde no necessity at all of a *Vacuum*” (*DCo* 4.26.4) in the experiment because nothing rules out the possibility that the whole apparatus may leak air. Hobbes imagined that the pressure of the mercury descending from the tube will act upon the ambient air at the surface of the vessel, so that “if the force with which the Quicksilver descends be great enough (which is greater or less, as it descends from a place of greater or less height) it will make the Aire penetrate the Quicksilver in the vessel, and go up into the Cylinder to fill the place which they thought was left empty” (*DCo* 4.26.4). Thus, at least in Hobbes's assessment, the Torricellian experiment gives no solid empirical reason in favor of the vacuum.

The reasoning Hobbes offered on the question of the vacuum is hardly free from difficulty, and I will not attempt to defend it. The reply to the Lucretian argument seems oddly question-begging, as Hobbes simply presupposes that motion is possible in a plenum, contrary to what the argument is intended to establish. An obvious problem with his reply to the Torricellian experiment is that very similar reasoning might undermine his favorite experimental evidence for plenism. If the hypothesis that fine particles of air might penetrate the column of mercury is legitimate, then surely a defender of the vacuum might make a similar appeal to unobservable pressures and suction forces to evade the plenist conclusions Hobbes derived from the experiment of the watering vessel. At best, then, Hobbes's reasoning does not make a decisive case for plenism. Still, it is important to recognize that Hobbes's procedure in reasoning about the vacuum is very much at odds with the kind of dogmatic, a priori adherence to plenism that some commentators have attributed to him.¹⁵

We have seen that Hobbes regarded some questions about the nature of space as unanswerable (namely those about the finitude or uniqueness of the world). He also held that some disputes about space (notably that over the vacuum) could be resolved only by empirical investigation. But he also thought that some doctrines concerning the nature of space and body were resolvable by a priori arguments. In particular, he held that the doctrine of rarefaction and condensation was an incoherent exercise in self-contradiction. The twin processes of rarefaction and condensation were invoked by Aristotelian natural philosophers who held that numerically the same body might gain or lose quantity, as when water rarefies to become vapor, or vapor condenses to become water.¹⁶ In Hobbes's estimation this

¹⁵ Shapin and Schaffer characterize Hobbes as a dogmatic adherent of plenism who had no interest in experiments. They assert that “What Hobbes was claiming . . . was that the systematic doing of experiments was not to be equated with philosophy: going on in the way Boyle recommended for experimentalists was not the same thing as philosophical practice . . . This experimental way and the philosophical way were fundamentally different: they differed in their capacity to secure assent among intellectuals and peace in the polity” (1985, p. 129).

¹⁶ The details of the doctrine are obscure enough to be left aside here. An oddity of the doctrine is that a rare body was taken (at least by some) to have *more* quantity in it than a dense one, contrary to our ordinary understanding of density and rarity. This derives from the fact that quantity is, in the words of Kenelm Digby, “nothing else but divisibility; and . . . a thing is bigge, by having a capacity to be divided” (1644, p. 9). Thus, a highly divisible body (such as a liter of water)

doctrine can be rejected on a priori grounds because it violates principles that follow from the concepts of space, body, and motion. According to Hobbes, it is a conceptual truth that “a Body keeps always the same *Magnitude*, both when it is at Rest, and when it is Moved,” (*DCo* 2.8.5). Moreover, whenever a body appears to change magnitude (as when a plant grows, or water evaporates), it is a priori certain that such a change can be due only be due to the motion and impact of material bodies that interact with the changed body.

The consequence of such Hobbesian principles is that talk of rarefaction and condensation is literally incoherent. In *Leviathan*, Hobbes complained that the doctrine supposes “there could be Matter, that had not some determined Quantity; when Quantity is nothing else but the Determination of Matter,” or that there could be a body “made without any Quantity at all, and that afterwards more, or lesse were put into it, according as it is intended the body should be more or less Dense” (*L* 4.46, 375). In either case, the result is that there can be no content assigned to the concepts, or (as Hobbes put it in his *Six Lessons*), “nature abhorres even empty words, such as are . . . *Rarefying* and *Condensing*” (*SL* 2; *EW* 7: 225).

It should by now be clear that Hobbes’s conception of space is far removed from the dogmatic, anti-experimental, “rationalistic” enterprise that some commentators have found in his philosophy. As we have seen, his rejection of the vacuum was not based on ignorance of or indifference to experimental evidence, nor did it stem from an a priori argument against the possibility of a vacuum in the style of Descartes. The existence of a vacuum is not an issue settled by the foundational notions in Hobbes’s natural philosophy, i.e. his account of space, time, body, motion, and causation. Thus, if the issue can be resolved at all, it must be resolved on the basis of experiment, and Hobbes held that the experimental evidence was solidly against the hypothesis of a vacuum. Similarly, such phenomena as gravity, the freezing of water, or the propagation of sound cannot be accounted for by deducing them from the first principles of natural philosophy. Hobbes insisted that “where there is place for Demonstration, if the first Principles, that is to say the Definitions, do not contain the Generation of the Subject, there can be nothing demonstrated as it ought to be” (*SL* Epistle; *EW* 7: 184). However, when we lack access to the causes of phenomena (and this is typically the case in the investigation of nature), we must content ourselves with hypothetical causes. As Hobbes framed the issue, the fact that we must speculate hypothetically about the inner workings of nature means that “in natural causes, all you are to expect is but probability” (*SPP*, ch. 1; *EW* 7: 11).

(Footnote 16 continued)

contains more quantity than a less divisible body of the same volume, such as a liter of granite. For an account of the doctrine in the context of Hobbes’s dispute with Wallis, see Jesseph (1999, pp. 136–142).

3 Hobbes on Space, Body, and Geometry

Hobbes drew a sharp contrast between the inherently conjectural enterprise that he termed “physics” and the a priori demonstrations characteristic of true *scientia*. In Hobbes’s words, “the Science of every Subject is derived from a praecognition of the Causes, Generation, and Construction of the same” (*SL* Epistle; *EW* 7: 183). As it happens, Hobbes held that there were only two fully demonstrative sciences: geometry and politics. In the case of geometry we can literally bring geometric objects into being by drawing lines and figures, while a science of the commonwealth can be founded on definitions that show how civil society is generated through human agreement. I will leave aside Hobbes’s claims to have founded the one true science of politics, but would like to close by paying some attention to his program for the foundations of geometry and see how it connects with his treatment of space.¹⁷

Traditionally, geometry was taken to be an abstract inquiry into the properties of magnitudes that are not to be found in nature. Dimensionless points, breadthless lines, and depthless surfaces of Euclidean geometry were not traditionally taken to be the sort of thing one might encounter while walking down the street. Whether such items were characterized as Platonic objects inhabiting a separate realm of geometric forms, or as abstractions arising from experience, it was generally agreed that the objects of geometry and the space in which they are located could not be identified with material objects or the space of everyday experience. This approach raises a number of difficult philosophical problems concerning the relationship between geometric objects or space and their physical counterparts. For Hobbes, however, there are no such problems, because there is and can be no distinction between geometric space and physical space. Further, Hobbes’s strict materialistic ontology requires that geometric objects be defined as bodies or as things produced by the motion of bodies.

Hobbes’s geometric ontology can be summarized fairly readily by re-writing the traditional Euclidean definitions of the terms ‘point’, ‘line’, and ‘surface’. A Euclidean point is defined as “that which has no parts” (*Elements*, 1, def. 1). Hobbes dismissed any such conception, remarking “That which is indivisible is not Quantity; and if a point be not Quantity, seeing it is neither substance nor Quality, it is nothing. And if *Euclide* had meant it so in his definition, . . . he might have defined it more briefly (but ridiculously) thus, *a Point is nothing*” (*SL* 1; *EW* 7: 201). The Euclidean definitions of line as “length without breadth” (*Elements* 1, def. 2) and surface as “that which has length and breadth only” (*Elements* 1, def. 5) fare no better, and for essentially the same reason. Instead of these definitions, Hobbes offered the following:

¹⁷ More on Hobbes’s program for geometry and his extensive dispute with John Wallis, Oxford’s Savilian Professor of Geometry, can be found in Jesseph (1999).

Though there be no Body which has not some Magnitude, yet if when any Body is moved, the Magnitude of it be not at all considered, the way it makes is called a LINE, or one single Dimension; & the Space through which it passeth, is called LENGTH; and the Body itself a POINT; in which sense the Earth is called a *Point*, and the Way of its yearly Revolution, the *Ecliptick Line*. (*DCo* 2.8.12)

Thus, a point is a body so small that its magnitude can be neglected in a demonstration, while a line is the path traced by a point in motion. A surface is then easily enough defined as the trace of a line in motion, and a solid is defined through the motion of a surface.

According to Hobbes, the benefit to be gained by these definitions is twofold. First, they purge geometry of a false ontology that supposes the existence of some sort of immaterial quasi-realm of non-physical objects distinct from physical space and its contents. Second, and perhaps more importantly, Hobbes's re-written definitions include the motions that generate lines, surfaces, and solids. This innovation, he thought, would found geometry on first principles that would give incontrovertible demonstrations and (he expected) would yield new theorems. As he explained

In that part therefore of my Book where I treat of Geometry, I thought it necessary in my Definitions to express those Motions by which Lines, Superficies, Solids, and Figures were drawn and described; little expecting that any Professor of Geometry should find fault therewith; but on the contrary supposing I might thereby not only avoid the Cavils of the Scepticks, but also demonstrate divers Propositions which on other Principles are Indemonstrable. (*SL* Epistle; *EW* 7: 184–85)

Hobbes illustrated the supposed superiority of his approach by considering the Euclidean definition of a circle as “a plane figure contained by one line such that all the straight lines falling upon it from one point among those lying within the figure are equal to one another” (*Elements* 1, d. 15). Hobbes argued that, although this definition gives an adequate characterization of a circle, it does not show how to generate such a figure, since “if a man had never seen the generation of a Circle by the motion of a Compass or other equivalent means, it would have been hard to persuade him, that there was any such Figure possible” (*SL* 1; *EW* 7: 205). Instead, a circle should be defined as the figure generated from the motion of a line about one fixed endpoint. With this definition in hand, Hobbes imagined that any question concerning the circle could then be answered. Having grasped the proper cause of the circle, the true geometer need do no more than deduce the properties of his own construction, and this (Hobbes thought) should make such problems as the quadrature of the circle readily solvable.

Employing definitions of geometric objects in terms of the motions that produce them, Hobbes concluded that he had developed a new geometric method, which he termed the “method of motions.” The method exploited his kinematic conception of the genesis of magnitudes to solve geometric problems; by attending to the motions that generate magnitudes such as curves, Hobbes convinced himself that he had hit upon a method that would make short work of even the most difficult problem.

In fact, this method has some important similarities with techniques employed by Gilles Personne de Roberval, although it lacked the power that Hobbes attributed to it.¹⁸

4 Conclusion

Hobbes's program for the foundations of geometry was a thoroughly *sui generis* endeavor, and it found no favor with the philosophers and mathematicians of his day. The same, of course, might be said about his doctrine of space. These two are closely connected, of course, and what connects them is Hobbes's obsession with accounting for absolutely everything in terms of bodies in motion. Geometry is not, as some had taught, a science devoted to exploring the properties of abstract objects in a non-physical space, nor is physical space some kind of mysterious substance distinct from material bodies. In the end, Hobbes held, what is truly real is simply bodies moving and colliding; everything else is some kind of effect produced by that ultimate causal principle. Whether this sort of minimalist materialism has anything to recommend it aside from its parsimony is a question for another day, but we can at least thank Hobbes for trying to see how far one can go on such a basis.

Acknowledgments I would like to thank participants in the "Theories of Space" conference at the Max-Planck-Institut für Wissenschaftsgeschichte for comments on the presentation that led to this paper. My references to Hobbes's works use the following system of abbreviations: *English Works* (Hobbes 1839a–1845a) is abbreviated *EW* with references to volume and page number; *Opera Latina* (Hobbes 1839b–1945b) is abbreviated *OL* with references to volume and page number; *Leviathan* (Hobbes 1651) is abbreviated *L*, with references to part, chapter, and page number; *De Corpore* (Hobbes 1655) and its English translation *Of Body* (Hobbes 1656a) are abbreviated '*DCo*', with references to part, chapter, and section; *Six Lessons* (Hobbes 1656b) is abbreviated '*SL*', with a reference to the Lesson number and to *EW* after a semicolon; *Seven Philosophical Problems* is abbreviated *SPP* with a reference to dialogue number and *EW* after a semicolon; *Critique du de Mundo* (Hobbes 1973) is abbreviated *CDM* with references to chapter, section and page number; *The Correspondence* (Hobbes 1994) is abbreviated *CTH*. References to Euclid's *Elements* are to the Heath edition (Euclid 1925), by book number and proposition/definition number.

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¹⁸ See Jesseph (1999, pp. 235–238) on Hobbes's method of motions; the connection with Roberval is explored in Malcolm (2002).

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