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Hobbes on natural philosophy as “True Physics” and mixed mathematics

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ABSTRACT

In this paper, I offer an alternative account of the relationship of Hobbesian geometry to natural philosophy by arguing that mixed mathematics provided Hobbes with a model for thinking about it. In mixed mathematics, one may borrow causal principles from one science and use them in another science without there being a deductive relationship between those two sciences. Natural philosophy for Hobbes is mixed because an explanation may combine observations from experience (the ‘that’) with causal principles from geometry (the ‘why’). My argument shows that Hobbesian natural philosophy relies upon suppositions that bodies plausibly behave according to these borrowed causal principles from geometry, acknowledging that bodies in the world may not actually behave this way. First, I consider Hobbes’s relation to Aristotelian mixed mathematics and to Isaac Barrow’s broadening of mixed mathematics in *Mathematical Lectures* (1683). I show that for Hobbes maker’s knowledge from geometry provides the ‘why’ in mixed-mathematical explanations. Next, I examine two explanations from *De corpore* Part IV: (1) the explanation of sense in *De corpore* 25.1-2; and (2) the explanation of the swelling of parts of the body when they become warm in *De corpore* 27.3. In both explanations, I show Hobbes borrowing and citing geometrical principles and mixing these principles with appeals to experience.

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> […] physics (I mean true physics), that depends on geometry, is usually numbered among the mixed mathematics.
>
> *De homine* 10.5 (Hobbes, 1994)

> […] all the sciences would have been mathematical had not their authors asserted more than they were able to prove; indeed, it is because of the temerity and the ignorance of writers on physics and morals that geometry and arithmetic are the only mathematical ones.
>
> *Anti-White* (Hobbes, 1976, 24; MS 6566A, f. 5 *verso*)[1]

1. Introduction

At several points, Hobbes argues that he has provided a unified system, with connections between geometry and natural philosophy.[2] Some scholars have taken this unity to result from deductive connections between geometry and natural philosophy.[3] In this

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[1] I cite by folio number MS fonds Latin 6566A (Bibliothèque nationale, Paris; critical edition is Hobbes [1973]). I have amended Jones’ translation to reflect Hobbes’s use of *moralis*.

[2] For example, in *De corpore* 6.6 Hobbes links what he calls “our simplest conceptions,” such as ‘place’ and ‘motion’, with generative definitions in geometry and, ultimately, with natural philosophy and morality (OL I.62). I cite Hobbes (2005) as EW and Hobbes (1839–45) as OL, followed by volume and page.

[3] Peters (1967), Watkins (1973), Hampton (1986), and Shapin & Schaffer (1985). My focus will be the relationship between geometry and natural philosophy, but other accounts of Hobbesian unity are also concerned with the relationship of politics to the other sciences. Those supporting the deductivist interpretation of the relationship between geometry and natural philosophy argue that there are also deductive connections between politics and the other sciences. However, others have seen Hobbes’s politics as disjoined from the other sciences (Robertson, 1886; Taylor, 1938; Warrender, 1957; for discussion, see also Sorell, 1986, 6). Whether Hobbes’s politics is related to the other sciences by a deductive connection or is disjoined is beyond the scope of the present paper.

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paper, I offer an alternative account of the relationship of Hobbesian geometry to natural philosophy by arguing that mixed mathematics provided Hobbes with a model for thinking about it. In mixed mathematics, one may borrow causal principles from one science and use them in another science without a deductive relationship. Natural philosophy for Hobbes is mixed because an explanation may combine observations with causal principles from geometry. In Hobbesian natural philosophy, one may appeal to everyday experience or experiments for the demonstration of the 'that' and borrow the 'why' from geometry.

My argument shows that Hobbesian natural philosophy relies upon suppositions that bodies *plausibly* behave according to these borrowed causal principles from geometry, acknowledging that bodies in the world may not behave this way. For example, Hobbes develops an account of simple circular motion in geometry and supposes that the sun moves the air around it by this motion. We do not know as a matter of fact that the sun causes this sort of motion, but we *suppose* that it does—Hobbes describes this as a "possible cause"—and then we explain various phenomena related to light and heat using it. As part of geometry, the principles about simple circular motion have certainty; we can know that simple circular motion has necessary effects. However, when we borrow causal principles related to simple circular motion within a natural-philosophical explanation we cannot know whether the sun actually operates by simple circular motion. As a result, in natural philosophy we have suppositional knowledge of the following form: *if* the sun causes simple circular motion *then* an effect of that propagated motion will be heat and light.

My argument proceeds in two stages. First, I consider Hobbes's relation to Aristotelian mixed mathematics and to Isaac Barrow's broadening of mixed mathematics in *Mathematical Lectures* (1683). I show that for Hobbes maker's knowledge from geometry provides the 'why' in mixed-mathematical explanations.[4] Next, I examine two explanations from *De corpore* Part IV: (1) the explanation of sense in *De corpore* 25.1-2; and (2) the explanation of the swelling of parts of the body when they become warm in *De corpore* 27.3. In both explanations, I show Hobbes borrowing and citing geometrical principles and mixing these principles with appeals to experience.[5]

2. Aristotle, Barrow, and Hobbes on mixed mathematics

2.1. Aristotle and Isaac Barrow on mixed mathematics

In *Posterior Analytics* I, Aristotle argues that "it is not possible to prove a fact by passing from genus to another, e.g., to prove a geometrical proposition by arithmetic" (75a38-39).[6] For Aristotle, one cannot "prove by any other science the theorems of a different one, except such as are so related to one another that the one is under the other—e.g. optics to geometry and harmonics to arithmetic" (*APo* I.7, 75b14-17). Aristotle argues later that for sciences such as optics the 'that' will come from one science while the 'why' will come from a science which is "above" it (*APo* I.9, 76a4-13). In optics one may borrow geometrical principles because he studies the objects of optics *qua* line and not *qua* object of sight (*Metaph* M.3 1078a14-16). In treating the objects of optics *qua* line, one treats a natural object as a mathematical object.

There has been some debate regarding the status of mathematical objects for Aristotle, given this account of mixed mathematics. Whereas Lear understands them as fictional objects (1982), Lennox views them as resulting from "taking a delimited cognitive stance toward an object" (1986, 37). In other words, one considers an object in a certain way. As I will discuss below, this is how Hobbes describes mathematical objects.

Hobbes's contemporary Isaac Barrow appeals to and revises Aristotle's account of mixed mathematics in his *Mathematical Lectures* (1685). It is worthwhile to compare Barrow's view to Hobbes's because of their similar outlook in mathematics, especially since both held, against John Wallis, that geometry had priority over arithmetic (Jesseph, 1993). In Lecture II, Barrow criticizes Aristotle and Plato for having distinguished pure from mixed mathematics by assuming that there are two kinds of things: intelligible things, the subject of pure mathematics, and sensible things, the subject of mixed mathematics (Mahoney, 1990, 185). Barrow argues that "there exists in fact no other quantity different from that which is called magnitude, or continuous quantity, and, further, it alone is rightly to be counted the object of mathematics…" (Barrow, 1685, 39; trans. Mahoney, 1990, 186). Since "magnitude is the common affection of all physical things," there is "no part of natural science which is not able to claim for itself the title of 'Mathematical'" (Barrow, 1685, 40).

Some have taken Barrow's criticisms of the pure/mixed distinction as a rejection of mixed mathematics.[7] However, one might instead view Barrow's criticisms as a broadening of the purview of mixed mathematics (Malet, 1997, 280ff). Indeed, Barrow continues in *Mathematical Lectures* to describe what will be the *new* mixed mathematical disciplines, if his account is correct. In a way that will resonate with Hobbes's comments from *De homine* 10.5, discussed below, articulates the properly understood relationship between geometry and physics as follows: "… to return to Physics, I say there is no Part of this which does not imply Quantity, or to which geometrical Theorems may not be applied, and consequently which is not some Way dependent on Geometry" (Barrow, 1734, 22; Barrow, 1685, 41). As support for broadening mixed mathematics beyond the normally included disciplines, such as optics or harmonics, Barrow favorably mentions Aristotle's claim in *APo* (79a13-16) that "the physician chooses the cause from Geometry" when explaining why circular wounds heal more slowly (Barrow, 1685, 40).

Seeing Barrow as broadening the purview of mixed mathematics will connect Barrow to Hobbes, but there are important differences from Aristotle for both. For example, Barrow and Hobbes include motion in geometry (Mancuso, 1996, 94ff), something which for Aristotle must be kept separate from mathematics

4 Hobbes uses "mixed mathematics" (*mathematicas mixtas*) in *De homine* 10.5 and in *Anti White*. For general discussion of "mixed mathematics" see Brown (1991). For discussion of making and causal knowledge in Hobbes's geometry, see Jesseph (1996, 88ff). Some connection has been made between Hobbes and others who see making as essential to scientific knowledge, including Bacon and Vico (Barnouw, 1980; Gaukroger, 1986). Pérez-Ramos (1989) argues that on Bacon's conception of science making, understood as manipulating nature and producing works, is the ideal of scientific knowledge. However, there are two significant differences between Hobbes and Bacon related to maker's knowledge: first, unlike Hobbes does, Bacon never explicitly appeals to making as the guarantee of scientific knowledge, so at best it is perhaps implicit in Bacon's view (Zagorin, 1998, 39); and second, Hobbes explicitly holds that we possess maker's knowledge *only* in geometry and civil philosophy, so he could never countenance, as Bacon does on Pérez-Ramos' account, that we possess maker's knowledge in natural philosophy.

5 Additional instances of Hobbes borrowing principles from geometry in natural philosophy beyond those I discuss include the following: *De corpore* 26.6 (OL I.349), 26.8 (OL I.353), and 26.10 (OL I.357). Each of these explanations borrows geometrical principles related to circular motion from *De corpore* 21 (they cite 21.10, 21.11, and 21.4, respectively). Hobbes similarly borrows geometrical principles from *De corpore* 22.6 and *De corpore* 24.2 in optics in *De homine* 2.2 (OL II.8) (Adams, 2014b, 39-40).

6 See also *Physics* II.2 and *Metaphysics* M.1-3 (esp. 1078a14-17). For discussion, see McKirahan (1978), Lennox (1986), Wallace (1991), and Hankinson (2005).

7 Mahoney (1990, 186). Similarly, Jesseph argues that Hobbes rejects the distinction between pure and mixed mathematics since Hobbes understands "body as the fundamental object of mathematics" (1999, 74-76). Nevertheless, Hobbes himself describes pure mathematics as that which treats quantities in the abstract (*in abstracto*), which is how he articulates the project of *De corpore* Part III, and takes "true physics" to be part of mixed mathematics (discussed below).