

“Laudamusque tuas, aeterne Geometer, artes.”¹

Thomas Hobbes is generally studied for his contributions to political thought, and not to mathematics, despite the substantial percentage of his work which is explicitly devoted to the latter. Indeed, while it is certainly not the case that there are no recent studies of Hobbes’s mathematical works, one is struck by the same “striking disproportion” between the Hobbes scholarship devoted to politics and that devoted to mathematics that was observed over twenty years ago.² Furthermore, much of what is written on the topic ends up repeating the thought that Hobbes was a “bad mathematician” without stopping to wonder if there is not an anachronism of “history by the victors” hidden in the judgment. In what follows, I wish to begin to redress this imbalance, and will suggest that study of Hobbes’s mathematical thought can both sharpen our understanding of the specific character of his political thought, and help to locate him more precisely in the general context of the seventeenth century. That is, my argument will be that the Hobbesian social contract cannot properly be understood without reference to Hobbes’s geometry.

Even a cursory glance at seventeenth-century sources suggests both that Hobbes viewed his own work as providing a geometric foundation for political philosophy, and that he was read as attempting to provide such a foundation. The epistle dedicatory to De Corpore, for example, makes explicit Hobbes’s endeavor to resituate the sciences according to both geometry and logic. After saying that the text “to an attentive reader versed in the demonstrations of mathematicians ... [is] clear and easy to understand,” he

proceeds to order the progress in the sciences, starting with the geometry of the ancients, and the “logic by which they were enabled to find out and demonstrate such excellent theorems” (EW I, vii/OL I, 1). He later adds, tongue only somewhat in cheek, that he takes civil philosophy to be no older than his own De Cive (*ibid.*). The epistle ad Lectorem repeats the move: Hobbes’s reader is advised to “imitate the creation;” in the first part of the text, about logic, Hobbes will “set up the light of reason.” The next two sections are concerned with definitions and geometry. It is only after this that Hobbes will consider human nature and, finally, society (EW I, xiii/OL I). The formulation in De Cive is even more striking: “whatever in short distinguishes the modern world from the barbarity of the past, is almost wholly the gift of geometry,” and “if the patterns of human action were known with the same certainty as the relations of magnitude in figures, ambition and greed ... would be disarmed, and the human race would enjoy such secure peace ... it seems unlikely that it would ever have to fight again.” (DC, epis. Ded. [OL II, 137]).

Hobbes’s move to geometry was not unnoticed by his contemporaries, many of whom complained about it. To cite two examples: John Eachard, in staging an anti-Hobbes dialogue, introduced the text by proclaiming that Hobbes “by a starch’d Mathematical method ... had cheated some people into a vast opinion of himself.”³ The Earl of Clarendon similarly opined that Hobbes would “erect an engine of Government by the rules of Geometry, more infallible then Experience can ever find out.”⁴ Those who did not object to the fact that Hobbes used mathematics--e.g., mathematicians--almost universally objected to how he used it. In particular, Hobbes was involved in a long-running dispute with John Wallis, the Saville professor of Mathematics at Oxford. Both

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parties to that dispute saw their positions as having theological and political consequence, and so neither missed any opportunity for criticizing the other. As Hobbes wrote to his friend and translator Samuel Sorbière, “my quarrel with him is not like the quarrel between Gassendi and Morin or Descartes. I was dealing at the same time with all the ecclesiastics of England, on whose behalf Wallis wrote against me. Otherwise I would not consider him the least bit worthy of a reply” (HC 429). Wallis had similarly complained to Christian Huygens that “our Leviathan is furiously attacking and destroying our Universities ... as though men could not understand religion if they did not understand Philosophy, nor Philosophy unless they knew Mathematics” and had found it “necessary that some mathematician should show him ... how little he understands the Mathematics from which he takes his courage.”⁵

That said, Hobbes’s disputes with mathematicians both steadily grew and lasted throughout his career, despite his having an early public reputation for geometric skills. Hence, in the 1640’s, he was invited, along with Descartes, Roberval and Cavalieri, to comment on a dispute between John Pell and Christian Severin Longomontanus over squaring the circle.⁶ By the mid 1650’s, this reputation was entirely gone, and it had begun to fray well before that. Descartes had referred as early as 1641 to Hobbes’s “most worthless ghost of a demonstration, in order to deceive the insufficiently attentive reader” (HC 98), and subsequently broken off correspondence with Hobbes partly because of Hobbes’s refusal to concede algebraic proofs which seemed obvious to him.⁷ By 1656, the mathematician Claude Mylon had written that neither he nor Huygens was able to find Hobbes’s “thoughts about the dimension of the circle ... comprehensible” (HC 315). A year later, Mylon was begging Hobbes not to publish further on the subject “if you

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want to preserve your reputation” (HC 479), to “stop thinking about this subject ... and apply yourself to more tractable matters” (HC 487) and to “spend your time more usefully than on this topic” (HC 490). Huygens wrote of his conviction that he was making the effort to refute Hobbes “utterly in vain - given that, in my opinion, he is incapable of being led thereby to admit his error” (HC 537), but nonetheless concluded that he hoped he could persuade Hobbes to “abandon his extremely unsuccessful study of the whole of geometry” (HC 538). In short: Hobbes’s difficulties in the study of geometry and his attempts to insist on geometry against arithmetic went well beyond his debates with Wallis. Hence, Wallis’s judgment of 1662 was common, whether or not it was just:

But now ‘tis so unhappily found out, that Geometry, which he thought his greatest Sanctuary, hath most failed him. Nor is there any Tribe of men whatever, who are lesse satisfied with what he writes, than those who understand Geometry And doubtlesse, what ever else he is not, he is le[a]st of all found to be a Geometrician.⁸

II.

On the one hand, this attention to geometry puts Hobbes in company with other early modern thinkers--Descartes and Spinoza come to mind--who at least nominally claim to proceed more geometrico, and whose work needs to be read through this claim. On the other hand, the combination of Hobbes’s subordination of geometry to logic and the virulent reactions of professional mathematicians suggests that what Hobbes means by geometric method, and by mathematics, is not a matter of self-evidence. Two points should be emphasized. First, Hobbes spent much of his career specifically opposing the efforts of the English algebraicists (of whom Wallis was the preeminent example).

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Hobbes's opposition to Wallis was total, but, as I will indicate, seemed to reduce to two points. On the one hand, Hobbes rejected the move to symbolization in algebra. On the other hand, he consistently prioritized synthesis over analysis as a method of obtaining knowledge and was suspicious of moves to establish parity between them.⁹ Algebra, then, combined the worst of all worlds: not only did it universalize the analytic art, but it did so without sufficient attention to its own method. The following comment, by one of the characters in Hobbes's 1662 Seven Philosophical Problems, is indicative:

I see you have wrested out of the hands of our antagonists this weapon of algebra, so as they can never make use of it again. Which I consider as a thing of much more consequence to the science of geometry, than either of the duplication of the cube, or the finding of two mean proportionals, or the quadrature of a circle, or all these problems put together (EW VII, 68).

Given Hobbes's almost fanatical commitment to his own efforts at solving the problems he lists, the comment is remarkable. More important to Hobbes even than squaring the circle is the use of geometric demonstration in refuting the use of symbolic algebra in mathematics. That no one but Hobbes considered any of his demonstrations about the circle convincing should not allow us to be distracted from the question they pose: what does it mean that Hobbes, who thought thinking and construction were almost synonymous, loved geometry but hated symbolic algebra?

Second, even the claim that Hobbes followed a Euclidean model of geometry cannot be straightforwardly made.¹⁰ In a 1666 text, Hobbes cites Clavius's introduction to his edition of Euclid, and suggests that geometric method is not self-verifying:

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Quibus verbis ... non artem ipsam, sed magistros laudat. Certitudo scientiarum omnium aequalis est, alioqui enim scientiae non essent: cum scire non suscipiat magis et minus. Physica, ethica, politica, si bene demonstratae essent, non minus certae essent quam pronunciata mathematica: sicut nec mathematica scientiis aliis certior esset, nisi recte demonstrataentur ea quae pronuntiat [By means of which words he praises not the art of it, but its majesty. The certainty of all the sciences is equal, for otherwise they would not be sciences: for “to know” does not admit of more or less. Physics, ethics, politics, if they are to be well-demonstrated, are no less certain than the pronouncements of mathematics, just as mathematics is not more certain than the other sciences, unless that which it pronounces is correctly demonstrated] (OL IV, 390).

The repeated emphasis on demonstrating “well” or “correctly” suggests the fundamental importance Hobbes assigned to the correct specification of the synthetic art as a guarantor of certainty. This indicates that for Hobbes the success of *De Cive* and his other political writings as political science hinges on refiguring politics as a demonstrable, synthetic science on the model of classic geometry. It also implies that Hobbes will resist efforts to found any of these sciences on analysis--thus repeating Clavius’s relegation of the “mixed sciences” to a lower status than geometry, at least insofar as they are mixed.¹¹

Following the passage on the certainty of the sciences, Hobbes proceeds to comment on, and emend, Euclid. His discussion of the “point” is instructive. According to Euclid, says Hobbes, a point is “cujus pars nulla est [that of which there is no part]” (OL IV, 391). He then presents a view of symbolization which grounds a difficulty in Euclid’s definition: “signum enim quanti nomen non est [a sign is not the name of a quantum]” (OL IV, 392). Euclid thus contains a hidden ambiguity:

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Etiam verba illa ... dupliciter intelligi possunt: aut pro indiviso; pars enim non intelligitur, nisi ubi praecesserit divisio: vel pro indivisibili, quod per naturam suam divisionis est incapax. In priori sensu, punctum quantitas recte dicitur; in posteriore, non item; cum omnis quantitas divisibilis sit [and these words ... can be doubly understood: either as undivided; for a part is not understood, unless preceded by division; or as indivisible, that which is incapable of division by its nature. In the former sense, a point is rightly said to be a quantity; in the latter, it is not so, for all quantity is divisible] (OL IV, 391).

In this distinction--and the nominalism it suggests--I think, lies the entirety of Hobbes's debate with the algebraicists. For now, note the nominalistic precision of Hobbes's solution to the ambiguity: "Punctum est divisible quidem, sed cujus pars nulla in demonstratone consideranda est [a point is indeed divisible, but no part of it is to be considered in a demonstration]" (OL IV, 392).

Two aspects of this emendation should be retained for initial emphasis. First, as I will indicate, a review of Wallis's work in particular suggests that the nature of quantity is one of the central issues at stake. Second, Hobbes's attention to the act through which a geometer constructs proofs, and the artificiality of those constructed proofs as somehow representing nature without at the same time mirroring nature both marks the modernity (if liminal) of Hobbes's thought and shows a remarkable consistency between the theoretical concerns of his geometry and his politics. As he quite explicitly says in The Elements of Law: "one [way of erecting a body politic] is by arbitrary institution of many men assembled together, which is like a creation out of nothing by human wit" (EL 20.1). The modernity of the process is marked by its reliance on an understanding of thought as constructive or poietic: thinking "brings forth" its objects, and the active presence of thought in the objects fundamentally separates them from "nature."¹² Correct method, then, attends to its own process of construction; insofar as thought occurs in language (which, as we will see, for Hobbes it always does), method must attend to symbolization.

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This somewhat anomalous hybrid--after reading thinkers like Descartes, one might expect that a commitment to construction would be conjoined to a commitment to symbolization--can perhaps be illustrated with reference to the epistle to another of Hobbes's mathematical works. He writes:

Of arts, some are demonstrable, others indemonstrable; and demonstrable are those the construction of the subject whereof is in the power of the artist himself, who, in his demonstration, does no more but deduce the consequences of his own operation. The reason whereof is this, that the science of every subject is derived from a precognition of the causes, generation, and construction of the same- and consequently where the causes are known, there is place for demonstration, but not where the causes are to seek for. Geometry therefore is demonstrable, for the lines and figures from which we reason are drawn and described by ourselves; and civil philosophy is demonstrable, because we make the commonwealth ourselves. But because of natural bodies we know not the construction, but seek it from the effects, there lies no demonstration of what the causes be we seek for, but only of what they may be (EW VII, 184).

From the above, one can readily recognize at least two things about Hobbes. First, his work can be seen as liminal, in that despite his emphasis on construction and although he will follow a constructive method in the natural sciences, the results will indicate a possible cause, not a necessary or even a probable one. At the same time, "man," considered politically, is not necessarily determined by nature, which is to say that if "man" is initially or immediately determined by nature, such natural determination can nonetheless be qualitatively changed by application of the principles of political philosophy. Whatever the "natural" determination of the human is will therefore become irrelevant to political thought except as a meaningless residuum left behind. Because the political art is demonstrable, political philosophy will begin with the correct determination (definition) of its own terms so that correct conclusions and consequences can be demonstrated from them. In this sense, and as Hobbes's emendation of Euclid on

the definition of “point” suggests, Hobbesian demonstration also differs radically from a purely Greek model: for Hobbes, but not for the Greeks, a demonstration creates the objects it demonstrates. In both instances--politics and geometry--the specific art in question is to be subordinate to the logic of this production.

In this respect, and despite its vocal opposition to Aristotle, Hobbes’s thought is concerned with order and method in the same way Aristotle’s was.¹³ Hence, although it was composed after Hobbes’s death, Wallis’s *Institutio Logicae* of 1687 will begin to make the differences between them clear. Although against what he takes to be the abuses of scholasticism--in particular, separated essences--Wallis will nonetheless purport to follow Aristotle: “Non quod ego hac in re Novator sim; sed ad doctrinam Aristotelicanm seu Peripateicam eas revocam, qui ab ea (sive scientes, sive, quod potius putaverim, nescientes) exorbitaverint [not that I am an innovator in this; but I will return to the doctrine of Aristotle those things (either sciences or, as I had thought better, non-sciences) which they had dragged out of it].”¹⁴ Wallis will also follow a version of Aristotle’s nominalism: “Ut sunt Man, cow, Horse, Sheep, &c ... Quae communi consensu significant (apud nos) ea Animalia quae his nominibus indigetare solemus [there are man, cow, horse, sheep, etc. ... which by common consent signify (among us) the animals which we are accustomed to indicate with these names]” (*Logicae*, 2). This suggests both Wallis’s proximity to and distance from Hobbes. In particular, although Hobbes shares Wallis’s nominalism, he is deeply suspicious of the regulation of meaning communi consensu.

From the point of view of geometry, matters come to a head in the definition of “quantity.” On Wallis’s account, quantity will be predicated of an accident, but then be

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retroactively applied to a substance itself. On the one hand, the move can be said to be a necessary component of treating mathematics symbolically, insofar as symbolization requires that a sign refer to something other than its obvious referent. On the other hand, Wallis provides no apparent regulatory apparatus through which this retroactive application could be guaranteed. It appears, on the contrary, to be somewhat ad hoc. He writes, in a passage the slippage of which is remarkable:

Quantitas (universam sumpta) est ea Notio (seu Mentis conceptio) secundum quam quaerere solemus de re quopiam, per Comparationis Adverbium Quam. Ut quam longum? Quam amplum? Quam grande? Quam Grave? Quam diu? Quam magnum? Quam multum? Quam multa? &c. Et quicquid sit de quo sic commode interrogare possumus, id omne ad hoc Praedicamentum referendum est [Quantity (universally taken) is the notion (or concept of the mind) according to which we are accustomed to ask of a given thing by means of the comparative adverb “how.” Thus how long? How wide? How large? How heavy? How long a time? How great? How much? How many? Etc. And it is thus something about which we are conveniently able to ask: it is referred by everyone to these predications] (Logicae, 26).

Quantity becomes, in other words, and quite explicitly, the equalizer among the qualia: all of the qualia can be measured through quantity, which is to imply that quality can be successfully reduced to quantity, or, to put matters in a more seventeenth-century idiom, that all quantities are homogenous. I will return later to the question of homogenous quantity; for now, let me note that Hobbes explicitly challenges this understanding of quantity.

In his first Lesson to Wallis, Hobbes says that “quantity” refers to “that which is signified by what we answer to him that asketh, how much any thing is” (EW VII, 192). He then cites Latin usage: the answer to “quantum est [how much] is not “magnitude or quantity, but ... tantum, so much” (EW VII, 192). As the quantum... tantum pairing suggests, quantity for Hobbes is a relational term, which is to say that quantity is always

quantity of something, and that the meaning of the quantity is always determined by the thing of which it is the quantity. On the one hand, this understanding suggests that for Hobbes, as for the Greeks, the question of calculation is ultimately a question of counting and thus is indissociable from the question of what is being counted.¹⁵ A number is not a sufficient referent, because the number as a mark can indiscriminately refer to many different things: “this putting off an unit sometimes for one line, sometimes for one square, must needs mar the reckoning,” and “it can be no otherwise when you so apply arithmetic to geometry” (EW VII, 64). Hence the English algebraists court absurdity, “for the same number is sometimes so many lines, sometimes so many planes, and sometimes so many solids,” and “any arithmetical account used in geometry” is false, “unless the numbers be always so many lines, or always so many superficieses, or always so many solids” (EW VII, 59-60).

On the other hand, that quantity is to be relational suggests that the Hobbesian attention will always be on both the discursive or conceptual space within which something is constructed and on the objects of that construction. In other words, Hobbesian attention will be focused not just on the appearance of something but on the rules under which it appears. Hence he will say that “to faintesthai itself” is the “most admirable” of natural phenomena (OL I, 316). Hobbes will also explicitly caution against the reification of numbers which results from inattention to the nature of quantity as relational. “Differe and the quantity by which they differ,” he explains to Wallis, “are quite of another kind. Differe ... differing, exceeding, is not quantity, but relation. But the quantity by which they differ is always a certain and determined quantity” (EW VII, 384). Hence, “it is necessary to the science of geometry to define what quantities are of

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one and the same kind, which they call homogeneous” (EW VII, 198). This is because “Homogeneous quantities are those which may be compared by ... application of their measures to one another; so that solids and superficies are heterogeneous quantities, because there is no coincidence or application of those two dimensions” (EW VII, 198).

Wallis does conclude his Logic with the account of referentiality that Hobbes suspected was missing, but it can hardly be an adequate account from a Hobbesian point of view. Rather, Wallis finds an originary homogeneity in matter, which he then declares to be sufficient to allow quantity to supersede other qualia. In an appendix to the Logic, Wallis attempts to demonstrate that “quantity does not really differ from the number of a thing.” He writes, citing Aquinas: “Per Rem Quantam, intelligo, Materiam; quae est adaequatum subjectum Quantitatis; cui primo inhaeret [by quantum of a thing I understand matter, which is the adequate subject of quantity, to which it first inheres]” (Logicae, 256). Having located quantity primarily in both number and matter, the proof is straightforward. He cites Suarez on the propositions that “Quantitas non differt à substantia quanta, plus quam Modaliter [quantity does not differ from the number of a substance, except modally]” (Logicae, 256); and “Quorum Mode non differunt realiter, ea nec ipsa differunt realiter; At modus substantiae & modus quantitatis non differunt realiter; Ergo nec ipse [that of which the modes do not really differ do not themselves really differ; and the mode of substance and the mode of quantity do not really differ; therefore they do not themselves [really differ]]” (Logicae, 257). The conclusion which follows, that “Substantia & quantitas sunt subjecta partialia ejusdem numero modi [substance and quantity are partial subjects of their mode by number]” (Logicae, 259) seems to go a long way toward naturalizing number.

Wallis does not content himself with this, and his “second assertion” is that “Probabile est neque modaliter differre substantiam à quantitate, sed tantum ratione ratiocinata [it is not probable that substance and quantity modally differ, but only by reason of ratiocination]” (Logicae, 260). Although this is a dialectical thesis in Aristotle’s sense, its verification would have striking consequences. The effect would be that continuous quantity turns out to be discrete, with the result being a sort of atomism that guarantees the intelligibility of the universe through number.¹⁶ The closing passage of Wallis’s Logic is striking: “Concludo igitur, quod materia & quantitas non distinguuntur inter se realiter, ut res & res, & (probabiliter) neque modaliter; sed tantum ratione ratiocinata, hoc est, ut inadaequati conceptus ejusdem rei [I conclude, therefore, that matter and quantity are not really distinguished among themselves, as one thing and another, and probably not modally either; but only by reason of ratiocination, that is, that by inadequate conception of the thing]” (Logicae, 262). Of the confusion of method and metaphysics--or, rather, of the essentializing moves in metaphysics--Hobbes has the following to say:

There is a certain Philosophia prima, on which all other Philosophy ought to depend; and consisteth principally, in right limiting of the significations of such Appellations, or Names, as are of all others the most Universall: Which Limitations serve to avoid ambiguity, and aequivocation in Reasoning, and are commonly called Definitions; such as are the Definitions of Body [etc.] ... The Explication ... of which, and the Terms, is commonly in the Schools called Metaphysiques; as being a part of the Philosophy of Aristotle, which hath that for title; but it is in another sense; for there is signifieth as much, as Books written, or placed after his naturall Philosophy; but the Schools take them for Books of supernaturall Philosophy (L 46, 463).

The point which Hobbes is trying to make here, in other words, is the same one that he made against Euclid: a point is something which is taken as such for the purposes of constructing a demonstration, but that usage of a point as axiomatic does not then imply

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that axioms are themselves part of nature. Hence, just as the original contract is constitutive of (and therefore prior to) the differentiation of the citizens in a commonwealth, so too is the original declaration of unity a logically prior act to the differentiation of the numbers in counting.

III.

At this point, we are in a position to see both the innovations of Wallis's Mathesis Universalis and the reasons that Hobbes thought those innovations were absurd. Recall Hobbes's commitments: the universe is composed of matter, which is continuous quantity. The correct science for the study of physics, then, is geometry, since it is the science of continuous quantity. Any numeration of this quantity--and this is where Hobbes parts company with both Wallis and Euclid--involves an act of construction on the part of the knower; this act should not be confused with a statement about the nature of what one is talking about. Since conscious construction is central to the endeavor, quantity becomes fundamentally a referential function and any expression of quantity requires symbolization. Since numeration involves symbolization, and since symbolization is equivocal, definitions are important; otherwise, the results are meaningless.

In establishing, at least as a matter of probability, that quantity and matter cannot be distinguished ontologically, Wallis attempts to bypass all of these concerns. As various commentators have observed, results are more important than precision for the algebraicists, and in fact many of their results did not receive rigorous demonstration until much, much later.¹⁷ The effect of Wallis's move is a collapse of continuous and

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discrete quantity as a matter of metaphysics, which allows Wallis to rewrite geometry as arithmetic. The move to algebra means that everything hinges on symbolization. Hence, Wallis laboriously derives numeration and symbols in the opening sections of his Mathesis Universalis. Since he will both push the question of the priority of continuous and discrete quantity into the metaphysical background and establish the identity between a point as a unit of discrete quantity and the number “1,” Wallis is in a position to derive a system of numeration which is complete and adequate. He secures the system of numeration against charges of equivocacy by establishing its pedigree in ancient texts--a move parallel to the “common consent” by which the meaning of words is secured. The ultimate sufficiency of the move is probably secured theologically: he derives the Latin numbers from the Greek and Hebrew (ch. 6), and then (ch. 7) derives the writing of numbers from the Hebrew alphabet (see esp. 45).

That Biblical Hebrew anchors the system not once but twice suggests that Wallis is relying upon something like Adamite naming. The question of the Tower of Babel can be avoided by showing the correspondence of Greek and Latin numeration with the Biblical Hebrew. All of this underscores at least two points. First, Wallis joins the algebraicists in stressing results over the precision of his system. As will be evident in the discussion of irrational numbers, he is much more concerned with the application of his method than its strict justification. Insofar as Hobbes both insists on classical models of precision and distrusts anything which sounds like the application of theology where it does not belong, their collision was inevitable. Second, one should pause to underscore the radicality of Hobbes’s nominalism. For example, in Leviathan, Hobbes explicitly

cites the tower of Babel as evidence for the irreducibly political nature of language (L 4, 25).¹⁸

In Leviathan, Hobbes says not only that numbers are words, but that numeration is the paradigm case of signification through words. This means that mathematical questions are political questions and that precision in one's system of signification cannot be settled by appeal to common usage. He writes:

The use of words in registering our thoughts, is in nothing so evident as in Numbering. A naturall foole that could never learn by heart the order of numerall words, as one, two, and three, may observe every stroak of the Clock, and nod to it, or say one, one, one; but can never know what houre it strikes. ... And he that can tell ten, if he recite them out of order, will lose himselfe, and not know when he has done: Much lesse will he be able to adde, and subtract, and performe all other operations of Arithmetique. So that without words, there is no possibility of reckoning of Numbers; much less of Magnitudes, of Swiftnesse, of Force, and other things, the reckonings whereof are necessary to the being, or well-being of man-kind (L 4, 27).¹⁹

The natural fool, in other words, is capable of individuation--“one, one, one”--but not numeration. And, most importantly, they are radically separate operations.

Wallis's ambivalent endorsement of surd numbers is exemplary of the sort of imprecision to which Hobbes objects. Ratio, says Wallis, is distributed into rational and irrational. “Irrationalis autem que veris numeris exhiberi non potest; ut, in quadrato, ratio Lateris ad Diagonium [Irrational is that which is not able to be shown by true numbers; as, in a square, the ratio of the side to the diagonal]” (Mathesis, 251). The alleged superiority of arithmetic to geometry hinges on this, since one can easily work with such ratios in Euclidean geometry. Wallis admits the possibility of irrational numbers by reading his prioritization of arithmetic quantity and numeration into the Greeks:

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Quippe λογω (praeter alia significata) etiam Ratiocinium sive Computum significat; unde Logista idem est qui Calculator sive Computator; atq; illud αλογον, quod calculum fugit, nec vero numero est explicabile; qua de cause & αρρητον & ανεχφωνητον dicitur, inexplicabile, ineffabile, inenarrabile: non quod omnino enarrari non possit, sed non veris numeris possit enarrari [Indeed λογω (beyond all other signification) also signifies considered or computed; from which logistic is the same as that which I calculate or compute; and, that αλογον, which flees calculation, is not explicable by a true number; which is the reason it is called both αρρατον and ανεκσφονατον, inexplicable, ineffable, unable to be explained in detail: not that it is altogether unable to be explained in detail, but not able to be explained with true numbers] (Mathesis, 252).

The equivocal “considered or computed,” suggesting that to consider is to compute (by means of number), mirrors the ambiguity with which Wallis treats the metaphysical question of quantity in matter as a question of probable reason, and with a similar result. Following the passage above, Wallis proceeds to show how to calculate with irrational numbers, showing how they are greater or less, multiples, and so forth. He even uses them in the calculation of proportion. From a Hobbesian point of view, the move is the height of absurdity: Wallis is ready to admit into his system, and then use, a symbol whose referent he knows to be impossible to specify. Hobbes puts the sum of the complaint very clearly: “since the beginning of the world there has not been, nor ever shall be, so much absurdity written in geometry” as in Wallis's books, “the cause whereof I imagine to be this, that he mistook the study of symbols for the study of geometry” (EW VII, 187).

On Hobbes's account, then, symbolic algebra fails to individuate its objects correctly. Number is always number of something, which means that part of a mathematical proof is the correct specification of its object domain. A proof which does not begin by such correct specification, or which slides between object domains through the symbolic function of numbers, is either uncertain or sophistic or both. If these

considerations help to explain why Hobbes and symbolic algebra were (so to speak) heterogeneous quantities, they do lead to the following difficulty: a distinctly anti-modern understanding of mathematics gives rise to the first distinctly modern understanding of politics. Indeed, Hobbes is willing to follow innovation in mathematics only through Viète--who insisted on the importance of homogenous quantity. Of Viète, Hobbes writes: “the way of analysis by squares, cubes, &c., is very ancient ... and was at the highest in Vieta” (EW VII, 188). Viète had devoted most of his *Ars Analytica* to discovering rules for producing and moving between equations in differing magnitudes (squares, cubes, etc.). Viète also declared that:

The supreme and everlasting law of equations or proportions, which is called the law of homogeneity because it is conceived with respect to homogeneous magnitudes, is this. ... Only homogeneous magnitudes are to be compared with one another.²⁰

IV.

The preceding comments concerning Hobbes's emphasis on construction but opposition to symbolization suggest that the Hobbesian innovation in political science, the one which makes it “modern” is not the social contract theory simpliciter. The state of nature and social contract turn out to be moments which are part of a larger constellation of thoughts; the Hobbesian innovation--the one that allows such a constellation--is that which declares that politics is a demonstrable science. On the one hand, the conviction that politics is demonstrable then generates the necessity to account for its phenomena in a regular way. This in turn generates the need to consider the members of a polis as indivisible units, as numbers of the same qualitative type. Civil philosophy will thus have to spend its labors on making sure that the members of the polis are, in all relevant

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senses, of the same qualitative type. One can only calculate with homogenous quantities-- which means that political philosophy must begin by establishing a referential field whose quantities are homogenous, in the same way that a proof in geometry begins by specifying what will count as a point. This will have to be a primary determination; otherwise, political science would make the same mistakes as symbolic algebra by treating different things as the same. For Hobbes, the determination that objects are the same (homogeneous, therefore able to be part of the same geometry and set of demonstrations) will found a science, rather than be determined by it. Also for Hobbes, the consideration of people in the state of nature as quanta will explicitly be a methodological one, and be presented as necessary for the existence of an adequate understanding of politics. Examples could be multiplied, but the following from De Cive is I believe the most striking:

If then men are equal by nature, we must recognize their equality; if they are unequal, since they will struggle for power, the pursuit of peace requires that they be regarded as equal. And therefore the eighth precept of natural law is: everyone should be considered equal to everyone. Contrary to this law is called PRIDE (DC 3.13 [OL II, 189]; emphasis in original).

On the other hand, although Hobbes, in positing the idea that those in the state of nature should be considered as equal, will indict Aristotle for saying that some people are slaves by nature, his ability to do that is consequent upon his having already negated the Aristotelian proposition that one aim at the amount of precision appropriate to one's subject matter.²¹ More precisely, the precision appropriate to politics will become geometric, with geometry in turn being understood as construction. This second maneuver quite precisely marks the emergence of poiesis as an epistemic principle in the thinking of politics. In sum, a brief glance at Hobbes's engagement with mathematics

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suggests that the correct investigation of the state of nature requires concurrent investigation of the poietic principle which makes it possible.

Notes

1. Hobbes, De Mirabilis Pecci (OL V, 331). Hobbes references are given parenthetically in the text and are as follows. DC: On the Citizen [De Cive, 1647], ed. and trans. Richard Tuck and Michael Silverstone (Cambridge: CUP, 1998), by chapter and paragraph; EL: Elements of Law, Natural and Politic, rpt. as Human Nature and De Corpore Politico, ed. J. C. A. Gaskin (Oxford: OUP, 1994), by chapter and paragraph; EW: The English Works of Thomas Hobbes, 11 vols., ed. Sir William Molesworth (London, 1839), by volume and page; HC: The Correspondence of Thomas Hobbes, 2 vols., ed. Noel Malcolm (Oxford: Clarendon Press, 1994), by page; L: Leviathan, ed. Richard Tuck (Cambridge: Cambridge University Press, 1991), by chapter and page; OL: Opera Philosophica quae latine scripsit omnia, ed. William Molesworth (London, 1839), by volume and page. Although I retain the Molesworth pagination, I refer to the current critical edition of De Corpore, ed. Karl Schuhmann (Paris: J. Vrin, 1999) [= OL I]. Unless otherwise noted, emphases are in the original text.

2. Wolfgang Breidert, “Les mathématiques et la méthode mathématique chez Hobbes,” Revue Internationale de Philosophie 33 (1979), 415-431: 415. The following recent work seems particularly worth study: Douglas M. Jesseph, “The Decline and Fall of Hobbesian Geometry,” Studies in the History and Philosophy of Science 30 (1999), 425-453; item, Squaring the Circle: The War between Hobbes and Wallis (Chicago: U. Chicago Press, 1999); Helena M. Pycior, Symbols, Impossible Numbers, and Geometric Entanglements: British Algebra through the Commentaries on Newton’s Universal Arithmetick (Cambridge: CUP, 1997), especially at 135-166; William Sacksteder,

“Hobbes: The Art of the Geometricians,” JHP 18 (1980), 131-146; item, “Hobbes: Geometrical Objects,” Philosophy of Science 48 (1981), 573-590; and Karl Schuhmann, “Geometrie und Philosophie bei Thomas Hobbes,” Philosophisches Jahrbuch 92 (1985), 161-177. I will cite other, more general studies, as appropriate.

3. John Eachard, Mr. Hobbs’s State of Nature Considered, In a Dialogue between Philautus and Timothy, rpt. ed. Peter Ure (Liverpool: Liverpool UP, 1958). Eachard elsewhere quips that “by his Logick I profited wonderfully: for it was there (and I must ever acknowledge it) that I first was instructed, to call Logick Computation: and there I learnt how to add and subtract Logically: also how to make use of Triangles, Circles, Parabola’s, and other Mathematical instances; instead of homo, lapis or canis: and that’s, upon my word, what I found there,” Some Opinions of Mr. Hobbs Considered in a Second Dialogue between Philautus and Timothy (London, 1673), sig. a4.

4. Edward [Hyde], Earl of Clarendon, A Brief View and Survey of the Dangerous and pernicious Errors to Church and State, in Mr. Hobbes’s Book, Entitled Leviathan (Oxford, 1676), 117. For a discussion of what Clarendon probably means by “experience,” see Peter Dear, Discipline and Experience: The Mathematical Way in the Scientific Revolution (Chicago: U. Chicago Press, 1995).

5. Qt. in Bird, “Squaring the Circle,” 229. In other words, academic concerns were overdetermined by other issues. Jesseph reads the dispute as primarily grounded in issues of university politics; see Squaring the Circle, 48-72. That discussion should be set alongside the one in Siegmund Probst, “Infinity and Creation: the origin of the controversy between Thomas Hobbes and the Savillian Professors Seth Ward and John

Wallis,” BJHS 26 (1993), 271-279, which emphasizes accusations of Cromwellianism, which were common among royalists. It is also worth pointing out that Hobbes enjoyed a much better reputation in France than England, and that his pairing of geometry and politics seems to have influenced both François du Verdus and William Petty. See Quentin Skinner, “Thomas Hobbes and His Disciples in France and England,” Comparative Studies in Society and History 8 (1966), 153-164.

6. See Probst, 275.

7. The other cause was a dispute over whether Hobbes had plagiarized from Descartes’ Optics. See Descartes’ explanation of himself to Mersenne, HC 100.

8. Hobbius heauton-timorumenos (London, 1662), 6-7.

9. On this priority, see, e.g., Pycior, 145ff; and Jesseph, Squaring the Circle, 224-246. As will be evident, that Hobbesian geometry is subordinate to logic is of central importance in understanding it. For a lucid discussion, see William Sacksteder, “Hobbes: The Art of the Geometricians.”

10. For evidence that Hobbes studied geometry much earlier than is generally supposed, and that his Euclid was heavily mediated by Proclus, see Schuhmann.

11. For a discussion of the mixed sciences and Clavius, see Dear, 32-62.

12. On the importance of construction to modernity, see David R. Lachterman, The Ethics of Geometry: A Genealogy of Modernity (New York: Routledge, 1989).

13. It should be noted that in both Wallis and Hobbes mathematics will be considered as the paradigmatic scientia, a considerable departure from Aristotle. On this, see Paolo Mancosu, “Aristotelian Logic and Euclidean Mathematics: Seventeenth-

Century Developments of the Quaestio de certitudine mathematicarum,” Studies in the History and Philosophy of Science 23 (1992), 241-265.

14. Institutio Logicae (Oxford, 1687), Dedicatio, nn. Hereafter cited in the text as Logicae, by page number.

15. On this immediate referentiality of number in Greek thought, see Jacob Klein, Greek Mathematical Thought and the Origin of Algebra, trans. Eva Brann (New York: Dover, 1968). For further discussion of quantity as relational in Hobbes (and thus not the same as numeration), see Sacksteder, “Hobbes: Geometrical Objects,” 580-590.

16. For Hobbes’s efforts against atomism in physics, see Steven Shapin and Simon Schaffer. Leviathan and the Air Pump: Hobbes, Boyle, and the Experimental Life (Princeton: Princeton UP, 1985).

17. This is emphasized both in Pycior, passim; and in Jesseph, Squaring the Circle, passim. The emphasis is perhaps an effect of Bacon and his emphasis on works as the measure of science.

18. In this regard it seems significant that Wallis chooses to demonstrate the virtues of his system of addition and subtraction by precisely dating the world according to the Mosaic account (Mathesis, 118-128). Hobbes was often (incorrectly: see L 31, 250) assimilated into those who denied the flood and insisted on the eternity of the world. See Paolo Rossi, The Dark Abyss of Time: The History of the Earth and the History of Nations from Hooke to Vico, trans. Lydia G. Cochrane (Chicago: U. Chicago Press, 1984).

19. It is perhaps worth noting that this is not one of the passages which is significantly changed for the 1668 Latin edition; if anything, the passage lends itself even more to a nominalist reading. For example, the central “he that can tell ten, if he recite them out of order, will lose himselfe, and not know what he has done,” becomes “is qui decem verba habet numeralia, nise ordine ea recitet, numerare usque ad decem non potest” (OL III, 26)--someone who has ten number words, unless he follows correct order, is unable to numerate all the way to ten.

20. François Vieta, Introduction to the Analytical Art, in Klein, Greek Mathematical Thought, 324.

21. Nichomachean Ethics, ed. and trans. Hippocrates G. Apostle (Grinnell, Iowa: Peripatetic Press, 1984), 1094b12. The “slaves by nature” line is at Politics, ed. and trans. Hippocrates G. Apostle and Lloyd P. Gerson (Grinnell, Iowa: Peripatetic Press, 1986), 1254b15-20. Hobbes indicts it most forefully at EL 17.1.