

## Newton on Matter and Space in *De gravitatione et aequipondio fluidorum*

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### Abstract

This paper explicates the concepts of matter and space that Newton develops in *De gravitatione*. As I interpret Newton's account of created substances, bodies are constructed from qualities alone, as configured by God. Although regions of space and then "determined quantities of extension" appear to replace the Aristotelian substrate by functioning as property-bearers, they actually serve only as logical subjects. An implication of the interpretation I develop is that only space is extended by having parts outside parts; material bodies are spatially extended only in a derivative sense, via the presence of their constitutive qualities or powers in space.

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Newton develops his account of material body in what Howard Stein has called the "creation" story or hypothesis. This account has also been called the "determined quantities of extension hypothesis" (Slowik, 2009), since Newton marks the account as speculative and develops it by associating various conditions with "determined quantities of extension".<sup>1</sup> I shall follow Stein's terminology, however, for reasons concerning Newton's account of minds, as explained later.<sup>2</sup> Understanding the account of body depends upon properly understanding these determined quantities of extension and their relation to space (extension) itself. It is therefore important briefly to review *De gravitatione*'s claims about space.

### Features of space

For Newton, space is an existence condition for any substance and "an affection of every kind of being".<sup>3</sup> This latter description refers to the manner of existing in nature, a manner of existing quite different from that of an abstract entity or a number, as J.E. McGuire has

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<sup>1</sup> See *De gravitatione* in *Isaac Newton: Philosophical Writings*, 27: "I am reluctant to say positively what the nature of bodies is, but I would rather describe a certain kind of being similar in every way to bodies..."; and 28: "And hence these beings will either be bodies, or very similar to bodies. If they are bodies, then we can define bodies as *determined quantities of extension which omnipresent God endows with certain conditions.*"

<sup>2</sup> See Stein, "Newton's Metaphysics", 275. Slowik refers to that account of bodies as the "Determined Quantities of Extension" or "DQE" hypothesis (see "Newton's Metaphysics of Space", 2009, 438.) I follow Stein's terminology in part to avoid reifying the quantities of extension, and in part for a reason concerning minds, as discussed at the end of §4.

<sup>3</sup> Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 21.

explained.<sup>4</sup> As space is an affection of every kind of being, so is it a condition for their existence. As Newton asserts in a well known remark, one repudiating the concept of spirits as transcendent, "No being exists or can exist which is not related to space in some way. God is everywhere, created minds are somewhere, and body is in the space that it occupies; and whatever is neither everywhere nor anywhere does not exist."<sup>5</sup>

Since space is an existence condition of substances, it is not surprising that Newton takes it to have its own manner of existing. It is neither substance, he emphasizes, nor accident.<sup>6</sup> That it is not an accident inhering in a subject means, in part, that as an affection of every kind of being, it cannot be localized to any one being. Accordingly, it is independent of bodies; if all bodies were annihilated, it would continue to exist unchanged.<sup>7</sup> Space more nearly resembles a substance than an accident, Newton indicates, and as we shall see later, he ascribes a degree of "substantial reality" to it. Indeed, he cites it as the one thing that can in some circumstances be conceived apart from God—a feature he will use to attack Descartes' account of matter as atheistic.<sup>8</sup> Yet though it has some substantial reality, still space is not a substance. For one thing, it is "not absolute in itself, but is as it were an emanative effect of God."<sup>9</sup> Its not being

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<sup>4</sup> Pointing to the manuscript 'Tempus et Locus' (c. 1692-93), as providing "Newton's most succinct statement of how place and time relate to existing things". McGuire explicates that statement as follows: "Newton answers the question: what is it for anything to exist in nature? It is to exist in a place and at a time. As the text implies, existing in place and time is what counts as actually existing, in contrast, for example, to existing in the manner of an abstract entity or as a number. This contention is supported by Newton's use of the phrase 'rerum natura' ....." (McGuire, "Existence, Actuality and Necessity: Newton on Space and time", 465)

<sup>5</sup> Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 25.

<sup>6</sup> Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 21-22. The ultimate source of Newton's view that space is neither substance nor accident is Renaissance thinker Francesco Patrizi da Cherso (1529-1597). Patrizi additionally held space to be wholly distinct from body, indeed a condition for matter's existence, and to be immutable, indivisible, and immobile. See F. Patrizi, 'On Physical Space' (*De Spacio Physico*), translated and commentary by B. Brickman, *Journal of the History of Ideas*, 4:2 (1943), especially 224-245. As Edward Grant explains (*Much Ado about Nothing*, 206-207), Patrizi is also the source of a surprising explanatory remark following Newton's claim that space has distinguishable parts, whose common boundaries may be called surfaces. Newton then goes on to explain that in space there are "there are everywhere all kinds of figures, everywhere spheres, cubes, triangles, straight lines, everywhere circular, elliptical, parabolical, and all other kinds of figures, and those of all shapes and sizes, even though they are not disclosed to sight....so that what was formerly insensible in space now appears before the senses....We firmly believe the space was spherical before the sphere occupied it, so that it could contain the sphere....And so of other figures." (Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 21-22).

<sup>7</sup> Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 22. See also 21: as "an affection of every kind of being", it is not a "proper affection" which is to say an action.

<sup>8</sup> See Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 31: "If we say with Descartes that extension is body, do we not manifestly offer a path to atheism, both because extension is not created, but has existed eternally, and because we have an idea of it without any relation to God, and so in some circumstances it would be possible for us to conceive of extension while supposing God not to exist?" On space's inability to produce effects, see *Newton: Philosophical Writings*, p 21-22, 34.

<sup>9</sup> Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 21. That space is not a substance cannot fully be explained by its dependence upon God, in virtue of being an emanative effect of God. For as will be emphasized later, Newton accepts not only the strong sense of substance but also the weak sense, which applies to things dependent upon God, in particular, created minds and bodies. Although I cannot here address the question of how Newton understands an emanative effect, I am sympathetic to McGuire's view that the relation of space to God is one of "ontic dependence". (See McGuire, "Existence, Actuality and Necessity: Newton on Space and time", 480: "the relation between the existence of being and that of space is not causal, but one of ontic dependence".) McGuire's view provides an alternative to the three that Gorham (September, 2011) identifies as

absolute could not by itself explain why it is not a substance; for neither are created substances absolute in themselves, being dependent upon God. Yet created substances have a different relation to God, precisely in virtue of having been created. There is also another important difference. Substances act, whereas space produces no effects.<sup>10</sup>

Though neither substance nor attribute, space is not nothing, Newton emphasizes, for it has properties. The properties he describes indicate a Euclidean space, three-dimensional, homogeneous, and infinite. Space is also eternal and immutable, and though parts may be distinguished within it, those parts are motionless and indivisible.<sup>11</sup> It is these features—the immobility and indivisibility of space’s distinguishable parts—that are especially significant for Newton’s account of body.

### **The creation hypothesis and the definition of body**

Newton develops his creation hypothesis in two stages, first ignoring mobility but subsequently introducing it. He begins from the realization that we can temporarily make regions of space impervious to other bodies by moving our own bodies into them, observing that this might somehow simulate the divine power of creation. By his will alone, God “can prevent a body from penetrating any space defined by certain limits”.<sup>12</sup> Such an entity would either be a body, or would be indistinguishable from bodies by us.<sup>13</sup> For if God made some region above the earth impervious to bodies and all “impinging things”, it would be like a mountain; it would reflect all impinging things, including light and air, and it therefore would be visible and colored, and would resonate if struck.<sup>14</sup>

These entities would be very similar to corporeal particles, Newton notes, except for this important feature: he has imagined them to be motionless. For an entity to be a body, or at least

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‘Independence’, ‘Causation’, and ‘Assimilation’. Gorham defends Assimilation, arguing that space and time are attributes of God, and indeed identical to God (and thus to one another); see Gorham, September, 2011, especially 289-92 and 298-304.

<sup>10</sup> As I argue in §4, Newton takes God to be identical to his attributes, and fundamental to his creative power, that is, omnipotence; yet in doing so Newton does not eliminate substance but rather gives a reductive account of it. I note here that I reject the interpretation recently advanced by Geoffrey Gorham, though his arguments are intriguing. According to Gorham, God is identical to his attributes, but his attributes include space and time, and hence he is identical to space and time. (See Gorham, September, 2011, especially 289-92 and 298-304). In §4, I indicate the difficulties I see with that view.

<sup>11</sup> Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 22, 25, 26.

<sup>12</sup> Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 27.

<sup>13</sup> Newton means to emphasize that we cannot know matter’s “essential and metaphysical constitution” (*De Gravitatione*, in *Newton: Philosophical Writings*, 27), or indeed the essence of any substance. This conviction reappears in later writings, including the General Scholium, where he writes, “We certainly do not know what is the substance of any thing. We see only the shapes and colors of bodies, we hear only their sounds, we touch only their external surfaces...But there is no direct sense and there are no indirect reflected actions by which we know innermost substances.”(*Principia*, 942.) In this respect his account of body is strongly empirical.

<sup>14</sup> Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 28.

to resemble bodies in all humanly perceptible ways, it must be mobile. He therefore now adds that the hypothesized entities are capable of being moved from place to place, and in a law-governed way, a feature that is relatively new to conceptions of body.<sup>15</sup> Additionally, the entities can stimulate perceptions in minds and be operated upon by minds.<sup>16</sup> The hypothesized entities are now just like bodies, being perceptible, and having shape, tangibility, mobility, and the ability both to reflect and be reflected. They therefore could be "part of the structure of things", just like "any other corpuscle".<sup>17</sup> This enables Newton to provide a definition of body (insofar as we can know them).

We can define bodies as *determined quantities of extension which omnipresent God endows with certain conditions*. These conditions are: (1) that they be mobile, and therefore I did not say that they are numerical parts of space which are absolutely immobile, but only definite quantities which may be transferred from space to space; (2) that two of this kind cannot coincide anywhere, that is, that they may be impenetrable, and hence that oppositions obstruct their mutual motions and they are reflected in accord with certain laws; (3) that they can excite various perceptions of the senses and the imagination in created minds, and conversely be moved by them, which is not surprising since the description of their origin is founded on this.<sup>18</sup>

One of the interesting things about this definition is that Newton sees it as serving theological goals, as will become evident from his commentary, and yet it is firmly rooted in experience. The fundamental features of our experience with bodies appear in the definition: their mobility; the mutual impenetrability that results in law-governed reflections of other bodies, light, and air; and the sensations they produce in us, such as those of color. Newton's remark at the end of the passage highlights the fact that experiences, specifically perceptions, make his description of the bodies' origin possible. For if bodies lacked the power to produce sensations, we could never have any ideas of them.<sup>19</sup> It is notable that Newton specifies condition (3), the

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<sup>15</sup> Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 28. In an otherwise quite different thought experiment, which appears in *Le Monde*, Descartes imagines bodies that move "in accordance with the ordinary laws of nature"; see CSM 1, 90. Of interest here is Katherine Brading's article "On Composite Systems: Descartes, Newton, and the Law-Constitutive Approach" (2011).

<sup>16</sup> "For it is certain that God can stimulate, our perception by means of his own will, and thence apply such power to the effects of his will." (Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 28)

<sup>17</sup> Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 28.

<sup>18</sup> Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 28-29. A definition given in 1678 by Robert Hooke contains some intriguing similarities. After asserting that the universe consists in body and motion, he writes, "I do therefore define a sensible Body to be a determinate Space or Extension defended from being penetrated by another, by a power from within." He also speculates that body and motion might ultimately be "one and the same". See Hooke, *Lectures Potentiae Restitutiva*, or of Spring, Explaining the Power of Springing Bodies, 1678, 338-340. How near the similarity really is, however, is a question I will not pursue here.

<sup>19</sup> Geoffrey Gorham interprets this remark very differently. On his view, Newton's remark that the description of bodies' origin is founded upon sensations indicates that he takes the capacity to produce sensations to be both necessary and sufficient for bodyhood. In connection with that claim, Gorham argues that Newton ultimately sees his conditions of mobility and impenetrability

power to produce sensations, as distinct from condition (2), impenetrability. One reason for distinguishing them is that in the hypothesis' context, the first creation of matter, impenetrability could not be sufficient to produce sensations in minds. For if any minds existed when God first created matter, no human bodies would exist to touch it, and so the mutual impenetrability of bodies could not then produce sensations in minds. Yet there is another explanation for including condition (3) as independent of condition (2): even in the context of actual experiences, Newton does not seem to consider sensations as explicable solely in terms of impenetrability. He rather seems to share a belief common in the early modern period—that while the contact of light particles with the eye and food particles with the tongue seem to play some necessary role, they are not sufficient for the production of sensation, and so some role must be attributed to God.<sup>20</sup>

The definition's third condition is thus the basis for Newton's claim that Descartes' account of matter leads to atheism, while his own confirms God's existence. As indicated above, he takes space to be the one thing sometimes conceivable apart from God, since it produces no sensations or other effects, and so by identifying matter with extension (space), Descartes allows that matter is conceivable apart from God.<sup>21</sup> For as Newton indicates elsewhere, "we find almost no other reason for atheism than this notion of bodies having, as it were, a complete, absolute and independent reality in themselves."<sup>22</sup> On his own account, bodies are not conceivable apart

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as superfluous; these "do no independent work of their own"(Gorham, Jan.2011, 24). I contest Gorham's conclusion about those conditions in §2.5.

<sup>20</sup> Here I disagree with Geoffrey Gorham, who argues that Newton actually intends his third condition, the capacity to produce sensations in minds, to resolve a problem about distinguishability (a problem that has concerned several commentators but did not, in my view, concern Newton, for reasons I indicate later in this section). On Gorham's view, if Newton did not intend his third condition to resolve that problem, it would be superfluous: "If the DQE's are impenetrable, they will be solid to touch, reflect light, perturb the air when struck, and so on. Since these are the means by which the senses perceive familiar bodies, why the need for God to affix also the special power to produce sensations? The answer seems to be that impenetrability alone is inadequate to distinguish bodies from the unfavored portions of absolute space." (Gorham, January 2011, 23). Yet as I have argued, Newton does not see the production of sensation as reducible to impenetrability, either in the context of matter's first creation, when no human bodies would exist even if minds did, or in his actual context, in which human bodies do exist. He takes a line similar to that found in Locke's *Essay*. Despairing of the ability of the mechanical hypothesis to reduce sensations to the shapes, sizes, and motions of particles, Locke suggests that the production of sensations must be attributed to God. Or, on an interpretation associated with Ayers, Locke thinks that we invoke superaddition because our powers of understanding are too limited to grasp how God might have enabled matter to produce sensations; my thanks to James Hill for discussion of the point.

<sup>21</sup> "If we say with Descartes that extension is body, do we not manifestly offer a path to atheism, both because extension is not created but has existed eternally, and because we have an idea of it without any relation to God, and so in some circumstances it would be possible for us to conceive of extension while supposing God not to exist?" (*De Gravitatione, Philosophical Writings*, 31). Interestingly, Newton's language here suggests the strong mental exercise that Descartes calls 'exclusion', as opposed to the weaker one of abstraction. For Descartes, a successful attempt to conceive something while actually separating or excluding another reveals that the two are really distinct, as opposed to being merely conceptually distinct but really identical; see Pr I.62, CSM, 214. Newton's phrase, "supposing God not to exist", suggests the strong mental act of exclusion; he suggests that space may be conceived while actually excluding God, by supposing him not to exist.

<sup>22</sup> *De Gravitatione*, in *Philosophical Writings*, 32.

from God, because their capacity to produce sensation cannot be so conceived, and that inconceivability is expressed directly by his definition's third condition.

### **Interpreting Newton's account: determined quantities of extension and the role of divine action**

Yet what exactly are the "determined quantities of extension" endowed with the three conditions that Newton asserts? The question is essential to an understanding of his account of body, but it also has implications for the nature and extent of divine providence, as we will see. It is often supposed that in his creation hypothesis, Newton takes God to create bodies from parts of absolute space itself. For example, Christopher Conn speaks of a body in *De gravitatione* as "nothing more than a divinely-modified region of space".<sup>23</sup> Geoffrey Gorham also takes Newton's determined quantities of extension to be parts of absolute space itself, contrasting the "favored regions of space", which God endows with powers, against the "normal" regions (though on his soft occasionalist interpretation, the favored regions of space are given only powers of producing sensations.)<sup>24</sup> If Newton were seeking some sort of substrate in which properties could inhere, space might initially seem suitable, since as noted earlier, he considers it

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<sup>23</sup> Conn, 1999, 316, n. 23. Alan Gabbey allows the possibility without committing to it, in the following passage: "But alternatively, and of equal possibility, the properties of bodies might be the result of God choosing to 'inform' extensions, parts of absolute space, with corporeality and mobility. The parts of absolute space that God can and perhaps does endow with the properties of bodies are as empty of matter as the *materia prima* of the scholastics is void of intelligibility, or bereft of existence. But there is a crucial difference. Each of these parcels of empty extension is a *quid*, and a *quale*, and a *quantum*, whereas *materia prima* is none of these." (Gabbey, "The term *materia* in Newton and the Newtonian Tradition", 16 in proofs). I implied this myself in an earlier article (Kochiras, 2009, 269).

<sup>24</sup> See Gorham, "How Newton Solved the Mind-Body Problem", January, 2011, 22: "Newton proposes that God creates bodies by imposing three conditions on certain regions of space or 'determinate quantities of extension' (DQE)." See also Gorham, "Newton on God's Relation to Space and Time: The Cartesian Framework", September, 2011, esp. 297, where he speaks of "a favored portion of extension".

As a result of taking this line, Gorham understands Newton's account of body as intended to respond to a problem of distinguishing the favored regions of space from the normal ones. The problem (a variant of which was raised by Bennett and Remnant, 1978), may be described by the following two claims. (i) Newton claims that the parts of space are immobile, and therefore the favored portions of space must be distinguishable from the normal parts of space in order to become mobile; yet (ii) the property of impenetrability cannot accomplish the task of making the favored portions of space distinguishable from the normal parts of space, because the normal parts of space are themselves impenetrable to one another precisely because they are immobile. This problem, and the need to resolve it, then motivates Gorham's interpretation of Newton's account of body. In Gorham's view, Newton intends the third condition of his account, i.e., the capacity to produce sensations, to resolve the problem, for in his view, that condition would be superfluous if not intended for that purpose. (Gorham writes, "Condition (3) solves this problem by ensuring that the favored regions of space stand out because God superadds to them something lacking from the unfavored regions: the power to produce sensations." Gorham, January, 2011, 23.)

But the third condition would not be superfluous absent that problem, as I argue in §2.5. Nor is it clear that the problem about distinguishability, which motivates Gorham's account, is genuine. For one thing, if God did modify parts of actual space, surely he himself could distinguish them from one another (as indeed he would have to be able to do, if he were to confer any properties at all upon them.) For another thing, as I argue, Newton's creation story and its associated definition of body does not suppose parts of space itself to be modified. And there is an even more important consideration: even if the problem were genuine, why should we allow the need to resolve it to color our interpretation of Newton's account, given that he himself is not addressing such a problem? Even if the problem were genuine, it should be invoked only to evaluate Newton's account, not to interpret it, since again, Newton himself is not addressing that problem.

to be more like a substance than an accident. Nevertheless, there are powerful reasons to deny that he supposes God to create bodies by modifying parts of absolute space itself.<sup>25</sup>

The starting point of the creation hypothesis, though hardly decisive, is potentially significant. That starting point is the observation that we can make spaces impenetrable by moving our bodies into them—an action that does not, notably, alter the nature of space itself. Also significant, I think, is the “metaphysical truth” that God “has created bodies in empty space out of nothing”<sup>26</sup>; to square his account with that truth, as he means to do, Newton cannot say that God creates bodies out of space, since space is not nothing. A consideration that should be decisive, however, is the nature of space as he describes it, together with the implications of supposing that actual parts of space figure in his creation story and definition. He described space as being eternal, immutable, immobile, unable to produce effects, and as having parts that are distinguishable but indivisible. To suppose that certain parts of space could be divinely modified, rendered able to produce sensations, solidified and set into motion, is to suppose a full contradiction of Newton’s claims. It is to suppose that space is not eternal, because some parts of it may be turned into bodies; that space is not immutable, because some parts could be made impenetrable and able to produce sensations; and that its parts are not immobile and indivisible, because some parts, once made impenetrable, could be torn away from their neighbors and set into motion. And if some parts could be torn away, what exactly would ensue—would space be left with gaps, or would additional space appear to fill the gaps?

These are the sorts of conceptual problems that Newton points to when clarifying the first condition of his definition. Mobility is the first stated condition with which determined quantities of extension are endowed, and since space is immobile, he immediately clarifies that he is not speaking about the parts of space itself, but rather about their quantities: “therefore I did not say that they are numerical parts of space which are absolutely immobile, but only definite quantities which may be transferred from space to space.”<sup>27</sup> Significantly, a quantity of some part of space is not identical to the part of space itself—after all, some numerically distinct parts

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<sup>25</sup> It should be noted that despite taking parts of space itself to figure in Newton’s account of body, Gorham ultimately defends a soft occasionalist interpretation, on which Newton takes the regions of space to be modified only to the extent of temporarily assuming powers to produce sensations in minds. For as noted in §2.5, Gorham argues that the first two conditions of Newton’s definition turn out to be superfluous, and the “favored” parts of space, instead of being made actually impenetrable and actually torn away from the “normal” regions of space, are simply “spatial occasions” for God to produce perceptions in minds. Denying that Newton takes the parts of space to be altered and torn apart seems especially important for Gorham since he also argues that space is ultimately identical to God. Therefore, allowing that space could be altered would not only conflict with Newton’s claim that space is immutable, it would also imply that God is not immutable; Gorham avoids that implication by arguing that conditions (1) and (2) of the definition “do no independent work”.

<sup>26</sup> Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 31.

<sup>27</sup> Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 28.

of space have the same volume. Thus as Newton's own clarification indicates (a clarification we should keep firmly in mind when he seems to stray from it by employing more abbreviated locutions<sup>28</sup>), it is a mistake to reify his determined quantities of extension, by mistaking them for parts of space itself.<sup>29</sup>

Since Newton associates only quantities with the qualities or powers identified by his three conditions, and not parts of absolute space itself, bodies are constructed from powers alone. Insofar as it is useful to speak in terms of subject and the properties predicated of it, the quantity of any given region of space in which the powers are present may serve as a logical (grammatical) subject, but the utility of such locutions should not lead us to suppose that bodies consist in anything beyond powers. There is nothing like a substrate. Rather, bodies consist in sets of powers, distributed at multiple points of one region of space if the body is resting, or at points of successive regions if the body is moving. This interpretation does require that Newton's first condition, mobility, be considered differently from the other two, in that mobility must apply to something. I therefore suggest that Newton takes bodies (insofar as we can know them) to consist in mobile sets of spatially configured powers for mutual impenetrability and production of sensation. These mobile sets of powers must somehow be unified, so as to maintain their characteristic configurations as they either rest or move through space, and I propose that he assigns the task of unifying them to God. The powers are unified and maintained as enduring configurations by God—by y<sup>e</sup> divine arm, to borrow a phrase that Newton uses elsewhere.<sup>30</sup> The divine will accomplishes the task that he takes to be performed in the Aristotelian account by prime matter or substrate.

This interpretation fits well with his emphasis upon perceived qualities as the basis of a substance. In one of the explanatory points following his definition of body, he explains that the

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<sup>28</sup> At one point, for instance, Newton speaks of the form that God "imparts to space". (*De gravitatione*, in *Newton: Philosophical Writings* 29) Because of such instances, commentators must choose between (i) accepting the surface meaning of such remarks and thus understanding bodies as mobile, solidified regions of space, while paying the price of implying a serious conceptual problem (the question of what would remain, if regions of space could be torn out) as well as conflicts with Newton's own claims (i.e., that space is immutable and immobile, and that his definition concerns definite quantities, not the numerical parts of space); and (ii) avoiding any conflict with his claims that space is immutable and immobile, while paying the price of implying that some of his locutions are abbreviated or careless. I argue for the latter option, as indicated throughout.

<sup>29</sup> My interpretation can be reconciled with the definition that Newton gives of body at the outset of *De gravitatione* (and I thank Eric Schliesser for reminding me, at the conference at Ghent, of the need to reconcile them). As is well known, the bulk of *De gravitatione* consists in a lengthy digression, in which Newton attacks Cartesian physics and addresses various metaphysical questions, including those focused upon here. But Newton begins the manuscript with the intention of treating the weight and equilibrium of fluids and of solids in fluids, and while still engaged in that project, he defines body as "that which fills place" (*De gravitatione*, in *Newton: Philosophical Writings*, 13.) On the interpretation that I develop, that definition can be retained, since a set of spatially distributed powers of mutual impenetrability will repel any other such set; and while such sets do not fill place by actually having parts outside parts, the phenomenal effect is the same.

<sup>30</sup> The phrase is from Newton's second letter to Bentley (17 January, 1692/93; 240 in Turnbull): "Secondly I do not know any power in nature weh could cause this transverse motion without ye divine arm."



entities he has described are no less real than bodies and may be called substances because “whatever reality we believe to be present in bodies is conferred on account of their phenomena and sensible qualities.”<sup>31</sup> And a remark elsewhere in the manuscript, which I discuss in more detail in a subsequent section, points to attributes as the basis of “substantial reality”. An interesting implication of my interpretation is that the extension of bodies is parasitic upon the extension of space. Since bodies are extended in virtue of the presence of their constituent qualities or powers in space—a view whose conceptual predecessor is a concept of immaterial spirits as spatially located powers, as noted later<sup>32</sup>—only space is extended in the sense of having parts outside parts, a complete reversal of the Aristotelian view that all extension is corporeal, an attribute of matter.

### **An objection and response**

Still, more needs to be said, because some of Newton’s remarks may seem to conflict with the interpretation I have given. In an explanatory remark claiming an advantage for his own account over that of the Aristotelians, he writes, “Extension takes the place of the substantial subject in which the form of the body is conserved by the divine will.”<sup>33</sup> This remark, which refers to extension itself, might make one wonder whether Newton does after all mean that God creates bodies by modifying regions of actual space.

I already noted a powerful reason to reject the view that this objection recommends, namely, that it conflicts with Newton’s own concept of space and his own clarification that his definition refers to definite quantities, not to numerical parts of space. It should also be acknowledged that the mere mention of extension (space) cannot by itself imply anything, since the mobility condition ensures that absolute space must play some role in Newton’s account and hence in any interpretation. Still, the remark figuring in the objection must be explained. To investigate

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<sup>31</sup> This claim appears in the second of the four explanatory remarks following Newton’s definition of body; *De gravitatione*, in *Newton: Philosophical Writings*, 29.

<sup>32</sup> For a discussion of concepts of spirits and space, see Kochiras, 2012.

<sup>33</sup> Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 29. I thank an anonymous referee for urging me to explain how my interpretation can accommodate that remark. The referee also suggests that the following remark may conflict with my claim that the powers comprising bodies are maintained by the divine will: “I do not see why God himself does not directly inform space with bodies, so long as we distinguish between the formal reason of bodies and the act of divine will. For it is contradictory that it [body] should be the act of willing or anything other than the effect which that act produces in space.”(Newton, *De gravitatione* in *Newton: Philosophical Writings*, 31.) Newton makes this remark while considering the question of whether God creates bodies directly, as opposed to delegating the task to some intermediary, and he is concerned to distinguish God’s action from its effects. The interpretation that I have given does not contravene that distinction. For the powers that God creates, which constitute the body, are the effect of his action and distinct from it; and his action of maintaining those powers in certain configurations is distinct from both the prior action and its effect.

Newton's meaning, then, I quote the remark in full, along with a second explanatory remark following his definition, which will help illuminate the one particularly at issue.

That for the existence of these beings it is not necessary that we suppose some unintelligible substance to exist in which as subject there may be an inherent substantial form; extension and an act of divine will are enough. Extension takes the place of the substantial subject in which the form of the body is conserved by the divine will; and that product of the divine will is the form or formal reason of the body denoting every dimension in which the body is to be produced.

Between extension and its impressed form there is almost the same analogy that the Aristotelians posit between prime matter and substantial forms, namely when they say that the same matter is capable of assuming all forms, and borrows the denomination of numerical body from its form. For so I posit that any form may be transferred through any space, and everywhere denote the same body.<sup>34</sup>

In both of these passages, Newton compares his account to the Aristotelian one, but the first repudiates the Aristotelian framework while the second points to a structural similarity between that account and his own.<sup>35</sup> We will need to understand that structural similarity as well as the criticism in order to understand the remark figuring in the objection. Newton's criticism of the Aristotelian account, as elaborated elsewhere in the manuscript, is clear enough: its notions of prime matter or substrate (substantial subject, here) and of a substantial form inhering in that

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<sup>34</sup> Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 29. These passages are the first and third explanatory remarks following Newton's definition of body. The original of the third explanatory remark (i.e., the second quoted here) reads: "Inter extensionem et ei inditam formam talis fere est Analogia qualem Aristotelici inter materiam primam et formas substantiales ponunt; quatenus nempe dicunt eandem materiam esse omnium formarum capacem, et denominationem numerici corporis a forma mutuari. Sic enim pono quamvis formam per quaelibet spatia transferri posse, et idem corpus ubique denominare."

(*Unpublished Scientific Papers of Isaac Newton*, 107.)

<sup>35</sup> An interesting interpretation of *De gravitatione* has been given by Benjamin Hill, who does not see the mere structural similarity that I take Newton to assert between his view and the scholastic one, but rather sees significant scholastic content in Newton's ideas ("Newton's *De Gravitatione et Aequipondio Fluidorum* and Lockean Four-Dimensionalism", 2003.) One point of agreement between my view and Hill's is that both deny that the determined quantities of extension figuring Newton's account of body are regions of actual space. Apart from that, however, our views differ in a number of ways. For one thing, Hill understands the account in terms of *extensio* interpreted as potentiality. He argues that Newton retains "the metaphysical structures of the Scholastics' hylomorphism but substituted into those structures extension for prime matter and impenetrability + mobility for substantial form." (Hill, 2003, 317) On Hill's analysis, these substitutions are possible because Newton's *extensio* (which is a quantity, and thus distinct from space itself) is similar to the Scholastics' prime matter in a crucial way: "In Newton's thought, extension was, like prime matter, *pura potentia*". (Hill, 2003, 318; see also 321: "Although he did not strictly adhere to it...Newton seems to have distinguished *extensio* from *spatium*. *Spatium* denoted physical space whereas *extensio* denoted the abstract and metaphysical extensive quantity.")

Although his interpretation is ingenious, I am not convinced by it, and the difficulties I see are instances of an objection he anticipates and addresses, namely, that he has exaggerated Newton's scholasticism (see Hill, 320-321). Specifically, I am not convinced that Newton distinguishes *extensio* and *spatium*, as Hill claims, or that he understands the former as *pura potentia*. In connection with this, Hill's interpretation does not easily accommodate Newton's claim that the scholastic notion of prime matter is unintelligible. If we suppose that Newton understood prime matter as *pura potentia*, it is not clear why he would attack it as unintelligible (particularly if we also suppose that Newton understood the determined quantities of extension figuring in his own account of body as *potentia*). His charge that prime matter is an unintelligible notion is explained, however, if we suppose that he understands and represents it uncharitably (as he often represents Descartes) as a propertyless substrate that is an actual, component in substances; and his attack upon the scholastic account suggests that that is the way he understands it, as I indicate in §4. For instance, Newton writes, "Further, they attribute no less reality in concept (though less in words) to this corporeal substance regarded as being without qualities and forms, than they do to the substance of God; abstracted from his attributes." (Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 32.) Here Newton takes the Scholastics to explain bodies in terms of a propertyless, corporeal substrate, and he criticizes them for attributing reality to this concept.

prime matter are unintelligible.<sup>36</sup> This charge motivates the advantage he claims for his own account: since extension "takes the place of the substantial subject", he avoids the unintelligible notion of prime matter.

Turning to the structural similarity, Newton takes extension (space) in his own account to be analogous to prime matter in the Aristotelian account; and form in his account (which he also refers to as the product of the divine will) to be analogous to their substantial form. Before proceeding, we must ask what could he mean by 'form' in connection with his own account. I think he means 'form' to refer to the extent and shape of the configured set of powers. For in a limited class of cases, the Aristotelians do take form to be little more than shape, and that is a use of the term that Newton can accept, even as he rejects the notion of substantial form more generally. Thus, when he writes that the form of the body is conserved by the divine will, he means that the spatial configuration of the set of powers is maintained by God's action, as I argued earlier.<sup>37</sup>

Proceeding, then, we next need to understand the relation Newton sees between prime matter and substantial form in the Aristotelian account, since that will enable us to understand the relation he asserts between extension and form in his own account.<sup>38</sup> He represents the Aristotelians to be saying the following. Since prime matter can be associated with any form, its association with any body, via a particular form, is merely contingent; and so it is the substantial form that individuates the body.<sup>39</sup> That is to say, although prime matter facilitates a body's

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<sup>36</sup> See, for instance 31-32 of *De gravitatione*. It may be remarked that the unintelligibility of Aristotelian substratum is due at least in part to Newton's portrayal of it as something already complete in itself, as opposed to an incomplete material principle, which together with a substantial form contributes to the production of a complete, accident-bearing substance. Also, Newton's representation of prime matter as lacking all qualities overlooks the view, held by all Scholastics other than strict Thomists, that prime matter possesses the capacity for extension (*extensio in potentia*), a point I owe to Dennis Des Chene. And the Scholastics did grapple with the question about prime matter's intelligibility. It may also be remarked that although Newton sometimes uses the term 'inhere' (or its cognates) in his own assertions—notably in Definition 3 of the *Principia*, which defines the *vis insita* (inherent force), also called the *vis inertia* (force of inertia)—he is not there employing the scholastic sense of the term. For as is eventually made clear via the explanatory remarks at the end of Rule 3, Newton means to contrast the *vis insita/vis inertiae* against relational forces, notably the gravitational force. Unlike gravity, the *vis insita/vis inertiae* is monadic—it belongs to the body itself.

<sup>37</sup> This reading is supported by his remark, at the end of the first passage, that the form denotes each dimension in which it is produced. That is to say, the form or spatially configured set it marks out the same dimension (quantity of space), as it moves through numerically distinct parts of space. To borrow *Principia* terminology, the set of powers provides a sensible measure of each space it occupies, by reflecting other such sets, including light.

<sup>38</sup> Alan Gabbey (forthcoming, 10), commenting upon both this passage and a similar remark that Newton makes in a much later text (Add 3965 (no. 13), ff. 422r) writes, "Right to end of his life Newton saw an analogy between the Peripatetic couple, *materia prima* and *forma substantialis*, and the Newtonian couple, the endlessly transmutable matter common to all bodies and their properties, phenomena available to one or other of the senses." (Gabbey, "The Term *Materia* in Newton and in the Newtonian Tradition", forthcoming, 12). I do not mean to imply that Gabbey accepts my interpretation of Newton's account of body, but I find his remark illuminating.

<sup>39</sup> Since matter can assume all forms, Newton implies, then if matter rather than form individuated substances, there would be only a single substance persisting, no matter how dramatic the change in qualities. As a point of clarification that I owe to Dennis Des Chene, Newton incorrectly implies in this passage that there was agreement among the Scholastics about the

existence (since both prime matter and substantial form are needed for the body to exist), it never really belongs to the body because its association with that body is contingent; and therefore, to refer to the body is really to refer to its form.

Newton sees the same sort of relation in his own account, writing that "any form may be transferred through any space, and everywhere denote the same body." Space facilitates a body's existence, in that the body's powers must be distributed in space—for as noted earlier, no being can exist without being somehow related to space. Yet any given region of space may be associated with any body, since any body may occupy or pass through it; and since that region's association with the body (set of powers) is contingent, it cannot be said to belong to the body. This is Newton's point when he writes that the form denotes the same body, even as it is transferred through different spaces. Thus the interpretation that I have given can make sense of the passages discussed. (And in fact it makes better sense of them than does the interpretation claiming bodies to be divinely modified parts of actual space. That interpretation cannot account for the contingent, transitory relation the passages assert to hold between a part of space and the form, for if a part of space were modified so as to become a body, its relation to the form would not be contingent or transitory.)

### **The account of body and the extent of God's providence**

In another of the explanatory remarks following the definition of body, Newton states that the entities he has described subsist "through God alone".<sup>40</sup> The interpretation I have given provides a specific way of understanding this: the entities subsist through God alone in that the sets of powers are unified and maintained in their configurations by divine action. Since this action is direct, God's providence is much greater than if he merely concurred with the bodies' continued existence. Still, Newton also leaves ample room for secondary causation, for as indicated earlier, he sees the account of body and thus God's direct action as limited to corpuscles. This suggests a view similar to that found in a much later text, Query 31 of the *Opticks*. Query 31 sidesteps the problem of cohesion at the sub-corpuscular level by suggesting that corpuscles are created by God, but it speculatively attributes the cohesion of aggregate

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principle of individuation. Des Chene further explains (in correspondence) that there was some agreement among them that "substantial form *would* individuate corporeal substance, were it not that matter can exist, by the absolute power of God, without form and even without quantity".

<sup>40</sup> *Ibid.* Newton, *De gravitatione*, in *Newton: Philosophical Writings*, 29.

bodies to interparticulate forces, and thus to secondary causes.<sup>41</sup> Here too, by restricting his account of bodies to corpuscles, Newton leaves the cohesion of aggregate bodies to secondary causes.

The role that Newton assigns to God in *De gravitatione* therefore falls considerably short of occasionalism. This is consistent with the expectations that he evinces in other texts. In a letter of 1680, Newton writes, "Where natural causes are at hand God uses them as instruments in his works".<sup>42</sup> And as I have argued elsewhere, Newton never endorses the hypothesis that God causes gravitational effects directly, and his ongoing search for an explanation expresses his expectation of secondary causes.<sup>43</sup>

I therefore disagree with the interpretation defended recently by Gorham, who attributes occasionalism to Newton, albeit a soft sort.<sup>44</sup> The occasionalism is soft in that God does not cause perceptions in minds directly, instead endowing varying regions of space with the power to do so, in a continuous creation of matter.<sup>45</sup> Yet it is still a kind of occasionalism, because Gorham argues that that the first and second conditions of Newton's definition of body are superfluous, doing "no independent work of their own",<sup>46</sup> and that bodies consist in only the powers to produce sensations. Regions of space are the "spatial occasions" for the sensations, and God creates matter continuously by creating the powers to produce sensations in varying regions of space.<sup>47</sup> Gorham claims a powerful advantage for his interpretation: it implies that Newton solves the mind-body problem, avoiding problems about mental causation "by embracing a quasi-idealistic ontology of matter."<sup>48</sup> Yet his interpretation requires us not only to accept that conditions (1) and (2) of Newton's definition are superfluous, but also that condition (3), the power to produce perceptions in minds, is not merely necessary for body-hood but also sufficient. Gorham reaches this latter conclusion partly through his reading of the comment that Newton adds to this third condition—that it is not surprising that bodies have the power to cause

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<sup>41</sup> An illuminating discussion of Locke and the foundational problem about cohesion may be found in James Hill (2004), "Locke's Account of Cohesion and its Philosophical Significance".

<sup>42</sup> Newton to Burnet, 1680; Newton, *The Correspondence*, II, 334.

<sup>43</sup> See Kochiras, 2009, 2011.

<sup>44</sup> Gorham indicates that he sees Newton as belonging to a tradition that locates the ground of causation in God's will (Gorham, January, 2011, 25).

<sup>45</sup> See Gorham, January, 2011, 24.

<sup>46</sup> Gorham, January, 2011, 24.

<sup>47</sup> See Gorham, January, 2011: "The continuous creation of matter amounts simply to the distribution within space of God's power to produce sensations"(24); and "various quantities of extension are the mere 'spatial occasions' for God to bring out our perceptions in the successive and law-like ways we associate with moving bodies."(25).

<sup>48</sup> Gorham, January 2011, 30.

perceptions in minds, "since the description of their origin is founded on this".<sup>49</sup> Yet there is a natural reading of that remark which does not require either dismissing the definition's first two conditions as superfluous or supposing the third to be sufficient. That natural reading, which I explained earlier, is simply that if bodies lacked the power to produce sensations, we could never have any ideas of them. The remark is an instance of Newton's oft-repeated acknowledgement that we can know only perceived qualities, not the "essential and metaphysical constitution" of things.<sup>50</sup> Since I reject the occasionalist interpretation, I also reject Gorham's conclusion that "Newtonian bodies do not seem to qualify as self-standing substances".<sup>51</sup> On my interpretation, Newton considers bodies to be created substances. This is a desirable result, since bodies would have to be substances in order for Newton to accept a substantial distinction between mind and body—and he does, as I argue elsewhere.

In closing, I suggest that the account of body Newton develops in *De gravitatione* might have indirectly helped facilitate a concept belonging to his later rational mechanics, that of point mass. On the interpretation I have given, his concept of body has as its conceptual ancestor a spirit which consists in causal powers, which lacks parts outside parts, and which is extended only in the derivative sense that its constituent causal powers are present in some extension. An entity consisting in spatially present causal powers, as opposed to one possessing parts outside parts, may more easily be conceived as existing in a larger or smaller area—even as contracted to a point. Thus the bodies of *De gravitatione*, which consist in powers of mutual impenetrability or resistance, might have helped facilitate Newton's realization that mass can be considered at a point. Or at least, because they lack parts outside parts, such bodies would not stand in the way of that realization.

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<sup>49</sup> *De gravitatione*, 29. There is another passage that Gorham interprets as showing that Newton takes condition (3) to be sufficient as well as necessary for being a body. In that passage, Newton is attacking the Cartesian view of matter:

"Let us abstract from body (as he demands) gravity, hardness, and all sensible qualities, so that nothing remains except what pertains to its essence. Will extension alone then remain? By no means. For we may also reject that faculty or power by which they [the qualities] stimulate the perceptions of thinking things. For since there is so great a distinction between the ideas of thought and of extension that it is not obvious that there is any basis of connection or relation [between them], except that which is caused by divine power, *the above capacity of bodies can be rejected while preserving extension, but not while preserving their corporeal nature.*"(Newton, *De gravitatione* in *Isaac Newton: Philosophical Writings*, 33-34; emphasis added)

Commenting upon this passage, and quoting the italicized portion, Gorham writes, "So, the capacity to produce sensations in minds is sufficient and necessary for a quantity of space to possess the nature of body. This explains why Newton privileges condition (3) when he introduces his theory of creation: "The description of their [bodies'] origin is founded on this" (*De Grav* 29)."(Gorham, January, 2011, 24.) I do not see how Newton's remarks imply that condition (3) is sufficient as well as necessary for body-hood, as Gorham takes it to do. There is certainly a way of understanding the passages that does not imply any such thing. As I read the passage, Newton is saying that if one mentally abstracts qualities such as hardness away from a body, one has abstracted away only something that is necessary to body, not everything, since bodies also have the power to produce sensations. He is saying that condition (3) is necessary to body-hood, but he is not saying that it is sufficient.

<sup>50</sup> *De gravitatione*, 27; Cf. *Principia*, 942.

<sup>51</sup> Gorham, January 2011, 24.

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