

WHAT IS IT TO BE LOCATED?

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ABSTRACT. The literature suggests two main answers to the question of what it is for a material object to be located at a region of spacetime. Both have a number of virtues. However, both suffer from well-known problems. According to one answer, location is a primitive relation with no informative metaphysical analysis. But this makes a number of necessary truths seem mysterious and leaves them unexplained. According to the other answer, to be located at a region is just to be identical to that region. But this is inconsistent with a number of independently plausible theses about material objects and their locations. In this paper, I explore a new theory of location and argue that it has the virtues of these familiar theories but not their vices. I then explore some further connections the new theory has with some contemporary issues in metaphysics.

What is it for a material object O to be located at a region of spacetime R ?¹ In searching for an answer, I am not just interested in searching for a necessary biconditional of the form: necessarily, O is located at R if and only if O bears some relation φ to R . I am looking for a metaphysical analysis of location; I am asking what location *is*.²

Philosophers who have written on questions involving location largely fall within two broad camps, and these camps suggest two natural responses to our question. Some take material objects to be distinct from

¹I am asking about *exact location* (also sometimes called *occupation*). See Casati and Varzi (1999), Parsons (2007) and Gilmore (2018).

²Two important notes. First, I will assume substantivalism about spacetime, but I will ignore complications arising from relativity theory. Second, I am not just looking for a conceptual analysis of location. I'm following a general kind of framework laid out in Dorr (2016) and Rayo (2015). In Dorr's ideology, I am looking for an informative answer of the form: to be located is to be F . And in Rayo's ideology: for it to be the case that O is located at R just is for it to be the case that φ . Of course, analogous questions can be asked about location in other frameworks. For instance, Markosian (2014), p. 75, asks: *in virtue of what* does an object occupy the region of space that it occupies? In this paper, however, I am interested in asking what location is.

(and share no parts with) regions of spacetime and thus take location to be a primitive relation. This suggests a first response according to which the question has no answer. That is, there is no informative metaphysical analysis of what it is for O to be located at R . I will call this *the primitivist theory of location*.³ Others identify material objects with regions of spacetime and thus have said things like: necessarily, O is located at R if and only if O is identical to R . This suggests an answer according to which being located at a region just is being identical to that region. I will call this *the identity theory of location*.

But each theory is vulnerable to well-known problems (which we will develop more carefully in due course). The identity theory is in tension with the plausible thesis that it is contingent where I am located. It is also in tension with the plausible thesis that a statue is distinct from the clay from which it is made, while sharing the same location. The primitivist theory, on the other hand, is consistent with these theses. However, the primitivist theory makes certain facts seem mysterious. Why is it necessarily the case that my body and its location have the same size and shape? And why is it necessarily the case that if my arm is a part of my body, then my arm's location is a part of my body's location? Unlike the primitivist, the identity theorist has a straightforward explanation of these facts. It would be nice to have a theory of location T with the following features:

1. T is consistent with contingent location.
2. T is consistent with two material objects having the same location.
3. T implies that necessarily, a material object has the same size and shape as its location.
4. T implies that necessarily, if x is located at R , y is located at S , and x is a part of y , then R is a part of S .

In this paper, I explore a new theory of location and argue that it has all four features. Unlike the identity theory, the theory I explore implies that material objects are distinct from their locations. But unlike the primitivist theory, it implies that material objects and their locations share parts.

³In the same spirit, some define exact location in terms of some other locative primitive; see Parsons (2007), for instance. The main points I make in this paper about primitivism will also apply to taking other locative relations as primitive, as well.

The point of departure is the assumption that so-called cases of *coincidence* are widespread. Consider a statue made out of a lump of clay. The statue and the clay seem to have different properties and so are distinct, by Leibniz's Law. Though distinct, the statue is very intimately related to the clay. Of course, the precise nature of this relationship (often called 'constitution') is a matter of controversy, and is not an issue I will get into here.⁴ However, if we accept the result that the statue and the clay are distinct, then there are two claims that seem very natural. First, the statue and the clay are the same size and shape. And second, the statue and the clay share parts with all and only the same things. Though the theory of location I develop does not imply that the statue is located at the clay, it takes the intimacy between the statue and the clay to be analogous to the intimacy between an object and its location. Being located at a region just is (what I will call) being *mereogeometrically equivalent* with the region.

Since the theory to be explored has some advantages over the primitivist and identity theories, I argue that it should be taken seriously. However, given the speculative nature of the enterprise, I am not claiming that the theory is completely cost-free. Along the way, I will also sketch some close rivals and argue that they too have a number of advantages. Though I will defend a particular answer to the question of what it is to be located, my larger goal in the paper is to raise an interesting question and explore the problems and merits of some different metaphysical analyses of location.⁵

In what follows, I briefly adapt some standard arguments to show that the identity theory fails to have features (1) and (2), and that the primitivist theory fails to have features (3) and (4). I then develop the new theory - *the mereogeometrical theory* - and argue that it has all four. In the last parts of the paper, I explore some connections the theory has

⁴Though see Wasserman (2017) for some details.

⁵A quick note on multilocation. There is a debate in the metaphysics of persistence literature about whether material objects are located at many different instantaneous regions, or if they are only located at their four-dimensional paths. See Gilmore (2018) for a discussion. For the sake of space, I will mostly ignore the issue of the possibility of multilocation. Though the background mereology assumed later in the paper is inconsistent with standard views of multilocation, it can be easily tweaked in order to be consistent with multilocation. With these tweaks in place, the view I will defend can be made consistent with multilocation and thus a major version of endurantism. Details will be sketched in footnote 26.

with a current debate about coincidence and a question about material objects and their shapes.

1. THE IDENTITY THEORY

In this section, I will briefly adapt some standard arguments to show that the identity theory fails to have features (1) and (2); that is, to show that it is not consistent with it being contingent where I am located and that it is not consistent with two material objects having the same location.

The identity theory says that for O to be located at R just is for R to be a region such that O is identical to R . This analysis implies the following necessary biconditional:

Necessarily, O is located at R iff R is a region such that O is identical to R . (LI)

The identity theory does not have features (1) or (2). Though this might look straightforward, it is worth considering a pair of arguments in a little detail. The identity theory identifies *being located* with *being identical to a region*. The arguments below rely on a higher-order version of Leibniz's Law which says that if being located just is being identical to a region, 'being located' and 'being identical to a region' are intersubstitutable.⁶ Following Dorr (2016), let ' $\varphi \equiv \psi$ ' express the higher-order identification that for it to be the case that φ is for it to be the case that ψ . Higher-order Leibniz's Law states:

$$\varphi \equiv \psi \rightarrow \chi[\varphi/p] \rightarrow \chi[\psi/p]$$

where $\chi[\varphi/p]$ is a sentence which is just like χ except that φ is substituted for free occurrences of the propositional variable p in χ .⁷

⁶It's worth noting that the arguments I'll present against the identity theory have close relatives which would work similarly against the mere necessary biconditional: necessarily, O is located at R iff R is a region such that $O = R$.

⁷See Dorr (2016), pgs. 48-49, for a couple of different versions of this principle. And see pgs. 50-51 for a discussion of how these principles relate to the issue of opaque contexts, generated for instance by attitude ascription reports, such as "Lois believes Superman can fly."

I will begin with the *argument from contingent location*. Suppose that I am located at R . The argument runs as follows:

5. There is a region R' distinct from R such that it is possible that I be located at R' .
6. But if the identity theory is true, then no region R' distinct from R is such that it is possible that I be located at R' .
7. Therefore, the identity theory is false.

Though I do not have a knock down argument for (5), I think it's very plausible. It's not a metaphysically necessary fact that I be located where I am in fact located. I could have been located elsewhere: there are a number of regions distinct from my location that I could have been located at.⁸

Next, (6) follows from higher-order Leibniz's Law and the necessity of distinctness, which says that if x and y are distinct, then they are necessarily distinct. And the necessity of distinctness follows from the necessity of identity⁹ and a very plausible schema for the logic of metaphysical necessity:

If p , then it's necessarily possible that p . (B)

(B) is widely accepted. As Williamson (2013) notes, "If something is so, then how could it have been metaphysically impossible?" (p. 44).¹⁰

The argument for (6) is as follows. Since I am located at R , the identity theory and higher-order Leibniz's Law tell us that R is a region that I am identical to. But for any distinct region R' , I am necessarily distinct from R' , by the necessity of distinctness. That is, no distinct R' is such that I am possibly identical to R' . But since according to the identity theory, being identical to R' is part of what it is to be located at R' , it is not possible to be located at R' . Therefore, if the identity theory is true, then no region R' distinct from R is such that it is possible that I

⁸This is something that should sound incredibly compelling to both endurantists who think that my locations are instantaneous regions and perdurantists who think that my location is my four-dimensional spacetime path.

⁹On which, see Marcus (1946) and Kripke (1971).

¹⁰See, however, Garson (2014) for some hesitation regarding (B). Also see Bacon (forthcoming b).

be located at R' . Thus, given the truth of (5), it follows that the identity theory is false.¹¹

Now for the *argument from co-location*. The argument runs as follows:

8. The statue and the clay are distinct and have the same location.
9. But if the identity theory is true, then no distinct things have the same location.
10. Therefore, the identity theory of location is false.

Famously, the statue and the clay seem to have different properties; they seem to differ modally, aesthetically, and so on. Therefore, by Leibniz's Law, the statue and the clay are distinct.¹² But even though they have different properties, they are both composed of the same particles and so are both located at the same region.¹³ And so (8) is true.

Next, (9) follows from higher-order Leibniz's Law and the symmetry and transitivity of identity. Given the identity theory, if it is the case that distinct things x and y are both located at some region R , then it is the case that distinct things x and y are both identical to region R , contrary to the symmetry and transitivity of identity. So if the identity theory is true, then no distinct things have the same location. Thus, given the truth of (8), it follows that the identity theory of location is false.

¹¹Of course, see Skow (2005) and Schaffer (2009) for the familiar counterpart theoretic response to the argument from contingent location, which rejects (5) – though note that they might instead reject (6). As I mentioned in my introductory remarks, I am assuming from the start that cases of coincidence are widespread. This follows from Leibniz's Law ($a = b \rightarrow \varphi[a/x] \rightarrow \varphi[b/x]$) and the assumption that we take modality seriously. Of course, it is certainly worth noting that counterpart theorists standardly reject unrestricted Leibniz's Law and thus reject the idea that the statue is distinct from the clay. But in this paper, we assume Leibniz's Law and thus the distinctness of the statue from the clay.

¹²This view has been developed and/or endorsed in Thomson (1983), (1998), Cotnoir (2010), (2013), (2016), Cotnoir and Bacon (2012), Hovda (2013), Walters (forthcoming), Gilmore (forthcoming), and Goodman (ms).

¹³I have in mind the particular case where the statue and the clay are permanently coincident, otherwise the identity theorist could opt for the standard temporal parts friendly view that the statue and the clay do not share the same location. Of course, see Sider (2001) for the familiar counterpart theoretic response to the case of permanent coincidence, which rejects the distinctness of the statue and clay.

2. THE PRIMITIVIST THEORY

In this section, I will briefly sketch some standard arguments against primitivism which stem from the fact that primitivism fails to have features (3) and (4); that is, from the fact that it fails to imply that necessarily, my body and its location have the same shape, and that necessarily, my parts' locations are a part of my body's location. The primitivist thinks that no informative analysis of location can be given.¹⁴ This is subject to the following family of complaints:

“Some material objects are spherical. Some regions of space are spherical. And it is necessary that every spherical material object is located at a spherical region of space. But this can't just be a magical, mysterious necessity, a necessity that must be unexplained.” (Skow 2007, p. 116)

“Why should there be this perfect correspondence between the mereological structure of things, and the mereological structure of the largest region they fill?” (Eagle 2016b)

Upon reflection, it looks like there is a tight correspondence between the geometrical and mereological structure of material objects and the structure of their locations. But to what extent are the structures aligned? This is a controversial question. Some think that the structures are perfectly aligned.¹⁵ And some think that the structures can come apart; for instance, some think that extended simples are possible, that material objects can interpenetrate, that co-location or multilocation is possible, and so forth.¹⁶ However, here are two facts:

Necessarily, if x is located at R , then x is the same size and shape as R . (G-HARMONY)

¹⁴It's worth noting that there are a number of possible answers to our question in this paper which are not primitivist about location, but about some other relation; for instance, the relation an object bears to configuration space; see Albert (1996). But in this paper, I am just interested in the location relation.

¹⁵See Schaffer (2009).

¹⁶See Gilmore (2018) for a thorough exposition of relevant views.

Necessarily, if x is located at R , y is located at S , and x is a part of y , then R is a part of S . (P-HARMONY)

(G-HARMONY) is a principle of geometrical harmony and (P-HARMONY) is among the weakest principles of mereological harmony discussed in the literature.¹⁷

(G-HARMONY) and (P-HARMONY) seem to cry out for an explanation. Why are they true? For the primitivist, this looks like a remarkable coincidence. On the other hand, the identity theorist has an explanation; (G-HARMONY) and (P-HARMONY) follow straightforwardly from the identity theory and Leibniz’s Law.¹⁸ But at first glance, it looks like the primitivist has no explanation for (G-HARMONY) and (P-HARMONY).¹⁹ Primitivism does not have features (3) and (4). Call that the *argument from explanation*.²⁰

A more precise and more controversial way of running the argument is sometimes defended in the literature. Some philosophers are attracted to the view that fundamental relations obey combinatorial principles. Though a number of combinatorial principles have been defended in the literature,²¹ they all aim to capture the thought that the world contains

¹⁷*Mereological harmony* is the rough idea that the mereological structures of material objects and their locations match. As far as I know, it was first discussed in Casati and Varzi (1999), pg. 122, though in terms of mereotopological structure (they call (P-HARMONY) “(L.3)”). Varzi (2007) develops a number of *mirroring principles* and the idea is developed in Uzquiano (2006) and (2011). Markosian (2014) formulates a biconditional version which he calls the subregion theory of parthood (STP). Saucedo (2011) develops an argument against the idea. I say it is among the “weakest” in the sense that it is perhaps the most uncontroversial mirroring principle, and it does not imply many other similar looking principles. See Uzquiano (2006), (2011), Leonard (2016), and Gilmore and Leonard (2020).

¹⁸*Supersubstantialism* is the view that material objects are identical to regions of spacetime. It is sometimes claimed that supersubstantialism can explain these necessary truths. But it is worth noting that it is the identity theory of location that explains them (which, of course, is a very natural theory of location for the supersubstantialist).

¹⁹This complaint is also made in Schaffer 2009, p. 138, Arntzenius 2012, p. 146, and Nolan 2014, p. 98.

²⁰Though there are a number of arguments against primitivism (see Schaffer (2009)), I focus on what I take to be the strongest. The other two main arguments are based on considerations of parsimony and modern physics. On the former, see Quine (1981), Lewis (1986), Sider (2001), Hawthorne (2006, Chapter 6), Nolan (2014), and Schaffer (2009). On the latter, see Schaffer (2009) and Lehmkuhl (2016).

²¹See McDaniel (2007) and Saucedo (2011) for relevant principles of recombination.

a distribution of fundamental properties and relations, and that these properties and relations can be freely recombined to represent different possible worlds. On this view, if location is primitive, any pattern of location should be metaphysically possible. In particular, there are patterns of location violating (G-HARMONY) and (P-HARMONY). Here is a quick argument:

11. If location is primitive, then any pattern of location is metaphysically possible.
12. If any pattern of location is metaphysically possible, then (G-HARMONY) is false.
13. (G-HARMONY) is true.
14. Therefore, location is not primitive.

A parallel argument can be given in terms of (P-HARMONY). In fact, Eagle (2016b) develops this sort of argument against locational endurantism (the view that material objects persist in virtue of being exactly located at many different instantaneous regions of spacetime).²² Eagle notes that this combinatorial argument also threatens perdurantism and suggests that the perdurantist identify material objects with their locations. Though I have not gone into the details in this paper for how philosophers have defended or rejected this argument, I will develop a theory of location which is compatible with the soundness of this argument.²³ However, it's worth stressing that one need not be tempted by controversial Humean principles of recombination to feel the pull of the argument from explanation: the primitivist theory lacks an explanation

²²Eagle argues that the endurantist must take the location relation to be primitive in order to adequately respond to Sider (2001)'s argument from vagueness, but then argues that since the endurantist must take location to be primitive, she faces the combinatorial argument.

²³The combinatorial argument is developed in depth in McDaniel (2007) and Saucedo (2011). Of course, my formulation of the argument was very quick. Primitivists have rejected premise (12) in a number of ways. McDaniel (2007), for instance, claims that material objects have their shapes in virtue of their locations' shapes. If one makes this move, then there is a route to explaining (G-HARMONY). We will come back to this idea in the last section. And Markosian (2014), for instance, reduces material parthood to subregionhood and claims that the mereological structure of objects is determined by the structure of their locations in order to explain (P-HARMONY).

of a number of necessary truths, and the identity theory has an explanation. All things considered, this clearly seems to count against the primitivist theory.

3. THE MEROGEOMETRICAL THEORY

Consider an arbitrary material object O and its location R . As we have seen, there are competing reasons for thinking that there are two things there and for thinking that there is really only one thing there. We have a modal reason to think that there are two things there: if O and R are identical, then O couldn't have been located somewhere else – and that seems false. And yet, O and R instantiate many of the same geometrical and mereological properties, and so we are pressured to say that there is really only one thing there. A similar situation arises when we think about the statue and the lump of clay. We have a modal reason to think that there are two things there: since the statue and the lump differ in their *de re* modal profiles, Leibniz's Law implies that they are distinct. And yet, they share many of the same geometrical and mereological properties, and so there is some pressure for thinking that there is really only one thing there.

The theory to be explored takes seriously the idea that the statue and the clay are distinct. Of course, one difficult question for those who take this idea seriously is: what *exactly* is the relationship between the statue and the clay? Without attempting to answer this question here, I want to return to the two straightforward observations I made at the beginning of the paper. First, they are the same size and shape. Second, they share parts with all and only the same things. According to the theory of location to be explored, these two observations are also true of material objects and their locations.

On this view, to be located is to be mereogeometrically equivalent with a region, where for x and y to be *mereogeometrically equivalent* (“MG-equivalent” for short) is for (i) x and y to be congruent and (ii) x and y to be mereologically coincident. For any O and R , what it is for O to be located at R just is for R to be a region such that O is congruent and coincident with R . Call this *the mereogeometrical theory of location* (“the MG theory” for short).

Let me briefly define these terms. First, say that x and y are *congruent* just in case x and y have the same shape.²⁴ Part of what it is to be

²⁴By “shape” I really mean size and shape. What is it to have a certain size and shape? Though not much turns on this, here is a first stab, supposing that space is Euclidean.

located at a region is to be congruent with that region. Second, say that x and y are *mereologically coincident* if and only if x and y overlap the same things (where x and y overlap if and only if x and y have a part in common); that is, for all z , z overlaps x if and only if z overlaps y . Part of what it is to be located at a region is to overlap all and only the same things as the region.²⁵ The MG theory implies the following necessary biconditional:

Necessarily, O is located at R iff R is a region such that O is MG-equivalent to R . (LM)

Though there are many regions of spacetime, one of them – my location – is a lot like me: it is the one with which I am MG-equivalent.²⁶

It is natural to take shapes to be those properties that can be analyzed in terms of the metric function d . For instance, what it is for x, y and z to be *three vertices of an equilateral triangle* is for there to be an r such that $d(x, y) = d(y, z) = d(z, x) = r$. See Skow (2007).

²⁵Related accounts of location have been mentioned in the literature. In fact, Hawthorne (2006, pg. 118) suggests a view on which location is reducible to mereological coincidence (see also Parsons (2007), f.n. 14). Gilmore (2014) develops this thought to show that there are a number of ways of accepting both multilocal endurantism and monistic substantivalism, the view that only spacetime regions are fundamental. And Kleinschmidt (2015) argues that part of what it is to be located somewhere is to have the same size and shape as that region. The view I am exploring is a combination of these ideas; later I will discuss why I think both components are necessary.

²⁶As mentioned in footnote 5, some think that persisting material objects are located at many different instantaneous regions of spacetime. Given the background mereology I have implicitly assumed (where parthood is absolute and 2-place), the MG theory is inconsistent with an object being located at two disjoint regions (if I am located at distinct regions R and S , then I am coincident with R and coincident with S ; since the relation *being coincident with* is symmetric and transitive, it follows that R and S are not disjoint). According to standard views of multilocal endurantism, though objects can gain and lose parts, they are nonetheless exactly located at many different disjoint regions. It is no news that such views are in tension with absolute 2-place parthood. As a result, endurantists standardly relativize parthood to times or regions. With this sort of tweak in place, an endurantist friendly version of the MG theory would say that to be located at a region R (at time t , or at region R) is to be congruent (at t or R) with R and coincident (at t or R) with R . The MG theory is consistent with multilocation so long as MG-equivalence is relativized: that is, so long as geometrical predicates and the parthood relation are relativized in the standard way.

The MG theory has a number of striking features. The first, again, is that material objects and regions share parts. The second is that located material objects are fusions of spacetime regions. Suppose O is located at R and that R is a fusion of some regions xx . Since O and R are coincident, whatever overlaps O overlaps at least one of xx .²⁷ The third is that it denies classical extensional mereology and relies on a non-extensional mereology. I will assume that parthood is reflexive and transitive; and when restricting the quantifiers to range over regions, I will assume that classical extensional mereology is necessarily true.²⁸ But when taking the quantifiers to range over both material objects and regions, I will reject the following principle:

If A and B are fusions of xx , then $A = B$. (UNIQUENESS)

(A is a fusion of xx just in case each x among xx is a part of A and every part of A overlaps some x among xx .²⁹) If (UNIQUENESS) is true, then the MG theory implies that location and identity are necessarily coextensive; that is, it implies (LI), and thus has no advantages over the identity theory.

These striking features deserve a pause. One might be worried: isn't the MG theory counterintuitive? Why go for a theory that implies, for instance, that I share parts with a spacetime region?

While conforming to intuition may be a theoretical virtue, it is by no means an overriding criterion for the evaluation of a theory. Other theoretical features of the theory such as, importantly, explanatory fruitfulness should be considered as well. A theory of location should be evaluated with respect to how well it does with respect to both of these criteria. If we took conforming to our intuitions to be an overriding criterion for acceptability, then we could discard the identity theory right away: after all, it implies that I am identical to a spacetime region! However, it would be misguided to reject the identity theory just because it is inconsistent with our everyday judgments. For the identity theory has other theoretical pay-offs, such as, for example, explanatory

²⁷The notion of fusion I am using here is what Hovda (2009) calls a *Type-1 Fusion*, where A is a fusion of $xx =_{df}$ for any y , y overlaps A iff there exists an x among xx and y overlaps x .

²⁸On classical mereology, see Simons (2000), Hovda (2009), and Varzi (2016).

²⁹Here I am relying on what Hovda (2009) calls a *Type-2 Fusion*, framed in standard plural logic.

fruitfulness: it has a straightforward explanation for (G-HARMONY) and (P-HARMONY). And though the primitivist theory is, obviously, not at odds with our everyday judgments (since it says nothing at all about what location is), it is explanatorily barren. The MG theory certainly has drawbacks, as does every theory of location. However, the MG theory is, all things considered, a better theory than its two main rivals. Or so I will now argue.

The MG theory has the four features with which we began:

1. T is consistent with contingent location.
2. T is consistent with two material objects having the same location.
3. T implies that necessarily, a material object has the same size and shape as its location.
4. T implies that necessarily, if x is located at R , y is located at S , and x is a part of y , then R is a part of S .

The first three are straightforward. The MG theory clearly has feature (1), since it is consistent with the theses that it is contingent what a material object's shape is, and what parts it has, and thus that it might have been MG-equivalent with a different region than it is.³⁰ Moreover, it clearly has feature (2). It is consistent with the statue and the lump both being congruent with a region R and overlapping all and only the same things as R (and in this case, all three would be MG-equivalent). It also has feature (3). Part of what it is to be located at a region is to be congruent with the region. And so the MG theory implies (G-HARMONY).

Moreover, the MG theory has feature (4). Suppose my arm (call it "Arm") is a part of my body (call it "Body"), that Arm is located at R_{arm} and that Body is located at R_{body} . Say that $x \sqsubseteq y$ iff everything that overlaps x also overlaps y . Since Arm is a part of Body, we know that $Arm \sqsubseteq Body$. Since R_{arm} and Arm are mereologically coincident, and since R_{body} and Body are mereologically coincident, we know that $R_{arm} \sqsubseteq Arm$ and that $Body \sqsubseteq R_{body}$; thus, we know that $R_{arm} \sqsubseteq Arm \sqsubseteq$

³⁰Indeed, the MG theory has an *explanation* for the contingency of location. It is contingent where I am located because it is contingent what my shape is and contingent what my parts are.

Body $\sqsubseteq R_{body}$. By classical extensional mereology for regions, it follows that R_{arm} is a part of R_{body} .³¹ Thus, (P-HARMONY) is true.³²

Before I move on to some connections the MG theory has with some current debates, I want to briefly respond to a few natural questions one might have about the theory. First, in explaining (G-HARMONY) and (P-HARMONY), one might be tempted to think that we have just pushed back the problem by introducing another brute necessity. Here, however, it is important to note that the MG theory is not simply the necessary biconditional (LM): necessarily, O is located at R iff R is a region such that O is MG-equivalent to R . The MG theory is a metaphysical analysis of what it is to be located. The analysis *identifies* being located with being MG-equivalent to a region and, as stressed by Rayo (2015) and Dorr (2016), identifications are a natural stopping place for explanation:

“Suppose it is agreed on all sides that Hesperus (and Phosphorus) exist. Someone says: ‘I can see as clearly as can be that Hesperus is Phosphorus; what I want to understand is *why*.’ It is not just that one wouldn’t know how to comply with such a request – one finds oneself unable to make *sense* of it.” (Rayo 2015, p. 54)

(G-HARMONY), (P-HARMONY), and (LM) are all explained by what location *is*. And since the MG-theory is an identification, it is a natural stopping place for explanation.

Note that a similar concern arises for those who think that material objects are identical to regions and who merely adopt the necessary biconditional (LI) – that is, necessarily, O is located at R if and only if R is a region such that O is identical to R – rather than the identity theory

³¹In particular, $x \sqsubseteq y$ implies that x is a part of y , by (STRONG SUPPLEMENTATION): if x is not a part of y , then there is some part of x which does not overlap y .

³²I should mention a brief word on what gets to count as an explanation for (G-HARMONY) and (P-HARMONY). I have argued that both the identity theory and the MG theory have an explanation for these facts because they have informative analyses about location which imply them. But I do not assume that these are the only sorts of explanations in metaphysics. Some might be skeptical about informative analyses and thus find the primitivist theory of location more attractive. There very well might be another route for explaining (G-HARMONY) and (P-HARMONY), which I leave as a challenge for the primitivist. Thanks to an anonymous reviewer for pointing this out.

itself.³³ Though (LI) and Leibniz's Law jointly imply (G-HARMONY) and (P-HARMONY), one might wonder: do we really have a satisfying explanation of (G-HARMONY) and (P-HARMONY)? What explanation do we have for (LI)? However, one virtue of the framework in which I am working is that the MG theory and the identity theory yield satisfying explanations for truths like (G-HARMONY) and (P-HARMONY), and do not themselves cry out for an explanation.

Second question. It is natural to suppose that coinciding objects have the same mass; moreover, it is natural to think that the statue inherits its mass from the clay. Since regions and material objects are coincident, do regions of spacetime have mass? This is an open question and the MG theory is non-committal, though I am inclined to think that the more natural answer is that material objects inherit their masses (and other magnitudes associated with fields) from the regions with which they are coincident.³⁴ In this respect, the MG theory is a lot like the identity theory in that it pins down fundamental magnitudes on to regions themselves.

Third, the MG theory has two parts. Do we need both? Why not go for a simpler view according to which being located at a region just is being congruent with the region? This would lead to a distinct view where material objects would be massively multilocalized at every region with which they are congruent, a view which I do not endorse.³⁵ Or why not go for the simpler view according to which being located at a region just is being coincident with the region? This is a more complicated question, and one which I will postpone until the final section of the paper.

Fourth, if a material object O and its location R are both fusions of the same regions, the rr , how is it that they can be so different? For instance, it is natural to suppose that region R has its subregions essentially. And so it is natural to think that R could not have been a fusion of regions other than rr . But if O is contingently located at R , then the MG theories implies that O could have been coincident with regions other

³³Principles similar to (LI) have been discussed in the literature. Parsons (2007) calls the following principle 'the identity theory of location': x is located at r if and only if x is identical to r . And Gilmore (2018) calls the following principle 'Supersubstantivalism+': necessarily, if x is located at r , then x is identical to r .

³⁴This idea is in Hawthorne (2006: pg. 188, fn. 18), Sattig (2006), Eagle (2010), Eagle (2016b: pp. 522-523), and is what Simon (forthcoming) calls *outsourcing accounts* of property possession.

³⁵Though see Bacon (forthcoming a).

than rr . But if O and R are both fusions of rr , how is it that O could be contingently coincident with rr but R not be contingently coincident with rr ?

This objection is an instance of the so-called grounding problem for coincident objects in general. Here are some other familiar variations. If the statue S and the lump of clay L are both fusions of the same particles, the xx , how is it the case that L can survive being stepped on but S not survive being stepped on? What *grounds* this difference? Moreover, it is natural to suppose that while S has its parts accidentally, L does not. But if both are fusions of the same particles, what else could ground this modal difference?³⁶ There are a number of responses to the grounding problem in the literature. And while I don't have a particularly novel response to this general problem for coincident objects, I will mention what I take to be the most satisfying response. I am inclined to adopt the view according to which nothing grounds these particular modal differences. It is simply a feature of statues that they cannot survive being stepped on (as opposed to portions of clay). And it is simply a feature of statues that they have their parts accidentally (as opposed to the matter that makes it up). If this is right, then, analogously, it is simply a feature of material objects that they could have been made out of different things (as opposed to regions).³⁷

Fifth, the MG theory says that being located at a region just is being MG-equivalent with the region. But this raises an interesting question. Can something be a location if it is not a region? Consider a simpler view (call this "the Simple MG theory") according to which being located just is being MG-equivalent with something. MG-equivalence is an equivalence relation that partitions objects into equivalence classes; thus, the statue, the clay, and a particular region R are all members of an equivalence class. According to the Simple MG theory, every member in a particular equivalence class is located at every other member; in

³⁶Many thanks to an anonymous referee for pushing me on these sorts of objections and raising a number of instances of this problem. For instance, if the MG theory is true, and if object O and region R are both fusions of the same spacetime points, then how is it that O could be a material object but not R ?

³⁷I mentioned above that it is natural to think that statues have their parts accidentally. One non-standard idea might be that regions too have their parts accidentally. If so, while the identity theory implies that a material object could not be located at a region other than itself, it perhaps might have been made out of different subregions, and thus could have been adjacent to other regions. Thanks to an anonymous referee for pointing this out.

particular, R itself is located at both the statue and the clay, and the statue and the clay are located at each other. Why not go for the Simple MG theory?³⁸

One might first appeal to the fact that we do not normally speak as if material objects are locations. But it is not clear how much weight we should give this consideration given that we are engaged in speculative metaphysics. Here are two more substantive arguments against the Simple MG theory. The first is that, depending on some details, the Simple MG theory might not imply (P-HARMONY) and thus fail to have feature (4). As before, suppose Arm is located at R_{arm} and Body is located at R_{body} . The Simple MG theory implies that R_{arm} is located at Arm and R_{body} is located at Body, as well. Now suppose that R_{arm} is part of R_{body} . From the fact that (i) R_{arm} is located at Arm, (ii) R_{body} is located at Body, and (iii) R_{arm} is a part of R_{body} , (P-HARMONY) tells us that Arm is a part of Body. But in order to conclude that Arm is a part of Body, we need to rely on (STRONG SUPPLEMENTATION). Though we assumed that this was necessarily true of regions, this is a principle that some philosophers deny when it comes to material objects (this will come up in the next section in more detail).

Here is a second argument. For any region R , R could not have been located somewhere other than where it is located. But there might have been a material object O located at R even though O is not in fact located at R . If the Simple MG theory is true, then R would have been located somewhere else (namely, at O). Therefore, the Simple MG theory is false. Though these two worries seem to me to count in favor of the MG theory, I take the Simple MG theory to be a view on the same team, rather than a competing rival.³⁹

³⁸Note that a similar question arises for the identity theory. Say that the *simple identity theory* is the view that what it is to be located just is to be identical to something. On this view, the number seven is located at itself. One might ask: why go for the identity theory rather than the simple identity theory?

³⁹It's also worth briefly thinking about other location relations. Following some ideas by Casati and Varzi (1999) and Parsons (2007), we can say that x is *weakly located* at R iff x is exactly located at a region S which overlaps R . In other words, x is congruent and coincident with a region S and R overlaps S . As Parsons notes, defining other relations in terms of exact location implies that anything with a weak location has an exact location, which some might find problematic. While I am aware that defining other relations in terms of exact location generates this worry, I do not attempt to resolve this difficult issue in this paper - see Leonard (2014) and (2018) for related issues. For a taste of location theories, see Casati and Varzi (1999), Hudson (2001),

4. COINCIDENTALISM

In this section, I explore some connections the MG theory has with a current debate about mereological coincidence. Say that *coincidentalism* is the view that some material objects are distinct and yet overlap the same things, and thus that (UNIQUENESS) is false. The theory of location we have been exploring takes seriously the view that the statue and the clay are distinct and yet overlap the same things. There are two rival versions of coincidentalism in the literature, corresponding to two sets of mereological principles. Both types of coincidentalists agree that the statue and the clay overlap the same things. After all, the statue and the clay are composed of the very same particles; and if A and B are both fusions of the same set of particles, then A and B overlap the same things. But whereas one group holds that the statue and the clay are both parts of each other, the other holds that it is only the clay that is a part of the statue (and not vice versa). This debate about the statue and the clay can be carried over to an object and its location: one group might say that an object and its location are parts of each other, and the other might say a region is a part of an object located at it (but not vice versa). Which view is right? I don't know; the MG theory is non-committal. But below I note some interesting consequences for each version of coincidentalism.

To clarify what these groups are saying, let's look at what principles they accept and deny. Notice that (STRONG SUPPLEMENTATION) and (ANTI-SYMMETRY) jointly imply (UNIQUENESS), and so coincidentalists must reject at least one of them:

If x is not a part of y , then there is some part of x which does not overlap y .
(STRONG SUPPLEMENTATION)

If x and y are parts of each other, then $x = y$.
(ANTI-SYMMETRY)

The first camp rejects (ANTI-SYMMETRY) and accepts (STRONG SUPPLEMENTATION). Following Gilmore (forthcoming), let *S-Coincidentalism* be the conjunction of (STRONG SUPPLEMENTATION) and the negation of (UNIQUENESS). If the statue and the clay overlap the same things,

Gilmore (2006), Sider (2007), Parsons (2007), Eagle (2010), (2016a), (2016b), and Kleinschmidt (2016).

it follows from (STRONG SUPPLEMENTATION) that the statue and the clay are parts of each other; that is, the statue and the clay are *mutual parts*.⁴⁰

In the spirit of S-Coincidentalism, suppose that we also take parthood to obey (STRONG SUPPLEMENTATION). From this it follows that objects and their locations are mutual parts. As we saw in the previous section, the MG theory of location implies (P-HARMONY). But without assuming stronger mereological principles like (STRONG SUPPLEMENTATION), it does not imply a number of further principles of mereological harmony.⁴¹ But in the presence of (STRONG SUPPLEMENTATION), the MG theory (like the identity theory) implies a particularly strong version of mereological harmony. From this it follows, for instance, that it is impossible for there to be extended simples (simple objects located at composite regions), for objects and their locations to differ in how many parts they have, and for gunky material objects (objects all of whose parts have proper parts) to be located in atomistic space.⁴² This all follows straightforwardly given the transitivity of parthood and the fact that objects and their locations are mutual parts, and thus stand in all the same parthood relations.

The other version of coincidentalism, *A-Coincidentalism*, is the conjunction of (ANTI-SYMMETRY) and the negation of (UNIQUENESS). From A-Coincidentalism it follows that the statue and the clay are not mutual parts. But A-Coincidentalists typically make an additional mereological claim: the clay is a part of the statue (and thus not vice versa).⁴³ In the spirit of A-Coincidentalism, what happens if we take parthood to obey (ANTI-SYMMETRY) and maintain that the location of an object is a part of the object (though not vice versa)? Given these assumptions, it turns out that the MG theory is *inconsistent* with a number of principles of harmony. For instance, it is inconsistent with: if x 's location is a part of y 's location, then x is a part of y . The statue and clay are both located at some region R , and R is a part of itself, but the statue is not a part

⁴⁰This view has been developed and/or endorsed in Thomson (1983), (1998), Cotnoir (2010), (2013), (2016), Cotnoir and Bacon (2012), Hovda (2013), and Gilmore (forthcoming).

⁴¹Though note that it straightforwardly implies the following principle of harmony: if x is located at R and y is located at S , then x overlaps y iff R overlaps S .

⁴²See Cotnoir (2013) for a discussion on how to define proper parthood for S-Coincidentalism.

⁴³This view is defended or discussed in Goodman (ms), Walters (forthcoming), and Gilmore (forthcoming).

of the clay.⁴⁴ It is also inconsistent with: if x is a proper part of y , then x 's location is a proper part of y 's location. The statue and the clay are both located at R , the clay is a proper part of the statue but R is not a proper part of itself. Moreover, it is inconsistent with: if x 's location is simple, then so is x . No simple object is located at a simple region.⁴⁵

5. MATERIAL OBJECTS AND THEIR SHAPES

In this final section, I return to a question posed earlier: why not go for a simpler theory – the *mereological theory* (or the “M theory” for short) – where to be located at R is to be coincident with R and for R to be a region? Why prefer the MG theory rather than the M theory? The main reason is that the M theory does not seem to have an explanation for (G-HARMONY). If I am located at R , and location is mere coincidence with a region, why is it that necessarily, my location and I have the same shape? Unlike the M theory, the MG theory has a straightforward explanation – being congruent with a region is *part of what it is* to being located at that region.⁴⁶

⁴⁴This is first observed in Cotnoir (2013), who argues that this is one reason to prefer S-Coincidentalism to A-Coincidentalism; though see Walters (forthcoming) for a response to this argument.

⁴⁵Setting aside the *S*- vs. *A*-coincidentalism debate, the MG view itself implies that if a point particle p is located at a point-sized region R , then they overlap (by the reflexivity of parthood). That is, p and R must have a part in common. Question: what is that part? Though the MG theory itself doesn't tell us, I will make three remarks about this case. First, I do not think we should identify the particle with its location, otherwise the worries raised earlier about contingent location and co-location would re-emerge for particles. Second, though the MG view itself doesn't tell us what part is common to both p and R , both *S*-coincidentalism and *A*-coincidentalism do tell us. The *S*-coincidentalism will tell us that p and R are both parts of each other; they are mutual parts. The *A*-coincidentalism will tell us that R is a part of p , but p is not a part of R . Third, note that while *A*-coincidentalism implies that p is not simple, the standard way of thinking about *S*-coincidentalism does not. As Cotnoir (2013) notes, there are independent reasons for which the *S*-coincidentalism ought to define proper parthood as $x < y =_{df} x \leq y \wedge y \not\leq x$, rather than the more standard $x < y =_{df} x \leq y \wedge x \neq y$. Notice that with this alternative definition, even though p and R are mutual parts, they are actually both simples, since neither has a proper part, that is, a part of which it is not a part. And so the *S*-coincidentalism can maintain that the MG view is consistent with the thesis that simple particles are located at simple regions (though, admittedly, for a kind of strange definitional reason).

⁴⁶Here is a related question from an anonymous referee: if two objects are fusions of the very same things, then isn't congruence guaranteed? Though strange, I can imagine a sort of model where coincidence and congruence come apart. Consider a

There is, however, an interesting route from the M theory to (G-HARMONY), by way of the following thought: perhaps the geometrical properties of material objects are reducible to the geometrical properties of their locations. That is, perhaps the geometrical properties of material objects are *inherited* from the shapes of their locations.⁴⁷

There are a couple of ways to make this idea more precise. First, an M theorist might adopt the following principle:

Necessarily, x has a material shape S iff x is located at some R and
 R has shape S . (INHERITANCE) \square

It might be tempting to appeal to (INHERITANCE) \square in order to explain (G-HARMONY); after all, it implies (G-HARMONY). However, (INHERITANCE) \square stands no less in need of an explanation than does (G-HARMONY) itself – both are necessary biconditionals. A more promising suggestion is to formulate the idea as an identification:

$(x$ has a material shape S) $\equiv \exists R(x$ is located at R and R has
 shape S) (INHERITANCE) \equiv

This says that for a material object to have a shape is for it to have a location with that shape. Unlike the necessary biconditional above, this principle implies (G-HARMONY) and stands in no need of an explanation, since it claims that the property of having a material shape S is *identical* to the property of having a location with shape S . The M theorist,

toy model with an object a which has a proper part b . In the model, a and b are parts of themselves, by the reflexivity of parthood, and b is a proper part of a , but a has no other proper part except for b , violating (STRONG SUPPLEMENTATION). Now suppose a is the size of a quarter, but b the size of a dime. Note that a and b are coincident: for any x , x overlaps a iff x overlaps b . Now suppose a is a region and b a material object. The M theory would imply that b is located at a , which seems wrong. Of course, some might find the above model metaphysically impossible. Note, however, that the S-Coincidentalists might not find anything mereologically suspect with the case, since they deny (STRONG SUPPLEMENTATION) anyway. For the purpose of this paper, I remain neutral about whether models like the one above are possible, and hence find it necessary to add in congruence to the MG theory, in addition to coincidence.

⁴⁷Again, see Hawthorne (2006: pg. 188, fn. 18), Sattig (2006), Eagle (2010), Eagle (2016b: pp. 522-523), and Simon (forthcoming).

therefore, is free to accept (INHERITANCE)_≡ in order to explain (G-HARMONY).⁴⁸

Moreover, it's worth noting that the M theory helps solve a little puzzle about geometrical inheritance principles. Consider the following plausible principle:

The shape of a material object is an intrinsic property.
(INTRINSIC)

Shapes are paradigmatic examples of intrinsic properties.⁴⁹ Of course, it is notoriously difficult to say just what it is for a property to be intrinsic. However, one very rough plausible idea is that my intrinsic properties are the ones which do not depend on what other things are like, other than me and my parts. In the same spirit, Skow (2007) writes: "A shape is intrinsic, then, just in case it can be completely analyzed in terms of the fundamental spatial relations among the parts of things that instantiate it" (pg. 115). (INTRINSIC) is plausible because it seems like what shape I am does not depend on what other things are like.

The puzzle is that (INTRINSIC) seems to be inconsistent with geometrical inheritance principles. (INTRINSIC) says that what shape I have does not depend on what other things are like, other than me and my parts. And inheritance principles say that what shape I have does depend on other things (in particular, my location). For this reason, McDaniel (2007) and Skow (2007) argue that one ought to reject (INTRINSIC).⁵⁰

However, the M theory solves the puzzle. Note that the M theory together with either S-Coincidentalism or (the spirit of) A-Coincidentalism implies:

If O is located at R , then R is a part of O . (REGION PARTS)

⁴⁸Indeed, the main argument philosophers like McDaniel (2007) and Skow (2007) have given for these sorts of inheritance principles is that they explain why it is that necessarily material objects and their locations have the same shape; that is, it explains (G-HARMONY). It's worth noting that though I formulate the principle in the framework of saying what it is for a material object to have a shape, McDaniel and Skow formulate the principle in terms of an object having a shape *in virtue of* being located at a region with that shape.

⁴⁹See Lewis (1983), (1986), (1988).

⁵⁰That is, assuming that material objects and their locations are distinct.

If (REGION PARTS) is true, then (INTRINSIC) and (INHERITANCE)_≡ are not inconsistent after all. If a material object is spherical, then one can consistently maintain that what it is for an object to be spherical is for it to be located at a spherical region, and that the object's being spherical is an intrinsic property of the object (since its location is a part of it).⁵¹

Is (INHERITANCE)_≡ true? I have a certain geometrical property: *having a material shape S*. Is the property of *having a material shape S* identical to the property of *being located at a region R with shape S*? I don't know. It is natural to suppose that material objects instantiate the *very same* geometrical properties that regions do. Indeed, it is natural to suppose that what it is for a material object to instantiate a geometrical property has nothing to do with its location.⁵² Moreover, the main reason to go for (INHERITANCE)_≡ is that it implies (G-HARMONY). But as we've seen, the MG theory already implies (G-HARMONY), so it's not clear what is to be gained by (INHERITANCE)_≡.

Furthermore, the MG theory and (INHERITANCE)_≡ are circular in a certain respect: the MG theory says that part of what it is for *O* to be located at *R* is to be congruent with *R* (that is, have the same shape as *R*), and (INHERITANCE)_≡ says that what it is for a material object to have a shape *S* is to be located at a region with shape *S*. Presumably, these sorts of circularities are to be avoided.⁵³ Those who find them problematic and who accept (INHERITANCE)_≡ can adopt the M theory. I happen to be agnostic about the truth of (INHERITANCE)_≡ and thus

⁵¹There is another version of coincidentalism in the literature according to which if *x* constitutes *y*, neither is a part of the other; see Lowe (2003). If we say that an object and its location are coincident and neither is a part of the other, the M theorist of course no longer has the resources to solve the puzzle, since she does not have (REGION PARTS).

⁵²Again, this paper is not the place to develop a metaphysics of shapes, but, presumably, the single analysis of what it is for a complex object (whether it be material or spatiotemporal) to have a shape *S* is to be spelled out in terms of the distance relations between its parts.

⁵³See Dorr (2016), pgs 70-79, who explores a number of No-Circularity principles. Dorr attempts to formulate a principle that distinguishes between benign and vicious circles and it is worth noting that the circularity between the MG theory and (INHERITANCE)_≡ violates the principle he settles for. This principle (which he calls *Only Logical Circles*) roughly states: "the case where the term on one side of a true identification occurs as a proper constituent of the term on the other side can arise only if all of the other expressions on the more complex side ... are or are equivalent to logical terms (p. 74)."

have developed the MG theory which can have both (G-HARMONY) and (INTRINSIC) without (INHERITANCE)_≡.

6. CONCLUSION

Though the primitivist and identity theories have a number of virtues, they also suffer from a number of problems. They are either inconsistent with the contingency of location and the possibility of co-location, or they leave a number of modal mysteries unexplained. The MG theory, on the other hand, has straightforward explanations for these modal facts. It's also consistent with the contingency of location and the possibility of co-location. Given these virtues, the MG theory is a better overall theory (as are some of the MG theory's close rivals, such as the Simple MG Theory and the M theory), and thus should be taken seriously as an answer to the question of what it is to be located.⁵⁴

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