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ORIGINAL RESEARCH

Enduring Through Gunk

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Abstract According to one of the more popular endurantist packages on the market, a package I will call *multilocational endurantism*, enduring objects are exactly located at multiple instantaneous regions of spacetime. However, for all we know, the world might turn out to be spatiotemporally gunky and spatiotemporal gunk (with some natural assumptions) entails that this package is false. The goal of this paper is to sketch a view which retains the spirit of multilocational endurantism while also recognizing the possibility of certain types of objects which endure through gunk.

1 Introduction

Endurantism is very commonly associated with the following slogan: enduring material objects are *wholly present* at each time at which they exist. But this slogan is very imprecise and comes with a number of problems.[1] This has led a number of endurantists to offer more precise characterizations of the view. For instance, some package endurantism as a *mereological* rejection of perdurantism, rejecting the idea that persisting material objects have proper temporal parts at each time at which they exist. Others package endurantism as a *measure-theoretic* rejection of perdurantism, rejecting the idea that persisting material objects are four-dimensional (and insisting that material objects fail to have temporal extent). And there are a handful of additional characterizations in the literature. In what follows, I want to

[1] See Sider (2001), pp. 63–68.

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focus on the endurantist package which has received most of the recent attention—the package which I will call *multilocational endurantism*. According to this package, the fundamental feature of endurantism concerns neither the notion of temporal parts nor the notion of temporal extent, but rather, the notion of a persisting object's *location*.[2] Proponents of this package maintain that enduring objects are objects which are exactly located at multiple regions of spacetime.[3] In particular, formulations of the view uniformly assume that enduring objects are located at multiple instantaneous regions of spacetime:

> [T]here are persisting material objects, and each of them has many different exact locations, each such location being instantaneous or 'spacelike'. (Gilmore 2014b)

> Spatiotemporal endurantism ... is a non-trivial picture of how ordinary objects are in spacetime, which mirrors the ordinary fact that an object itself exists at different times, by letting the object itself occupy multiple instantaneous spacetime regions. (Sattig 2006, p. 61)

> [T]reating moments of time as maximal instantaneous regions of spacetime, an enduring object that entirely fills some region R is exactly located at each time-slice of R. (Eagle 2016b, f.n. 15)

However, a natural worry presents itself. For all we know, spacetime might not contain any spacetime points and thus not contain any maximal instantaneous regions of spacetime. In particular, spacetime might be gunky, where something is *gunky* iff all of its parts have proper parts.[4] There are a number of reasons one might think that spacetime is not composed of extensionless points (and thus that there are no times which are maximal instantaneous regions of spacetime). First, there are some well-known conundrums which arise for the pointy conception of regions (for instance, how can uncountably many zero-dimensional points form an extended region?). Second, there are some reasons from modern physics; Arntzenius (2004), for instance, argues that considerations from quantum mechanics suggest that spacetime is not pointy.[5] Third, it seems genuinely epistemically possible for

[2] What I call the mereological, measure-theoretic, and multilocational variants of endurantism correspond roughly to what Effingham (2012) calls populationism, dimensionalism, and occupationalism, respectively.

[3] With the multilocational endurantist, this paper will assume that spacetime substantivalism is true, i.e., that spacetime regions exist and are not reducible to spatiotemporal relations among material objects. This paper will also ignore complications from relativity theory.

[4] The term 'gunk' was coined by Lewis (1991), who used it to refer to infinitely divisible atomless objects. There are other ways a world might not contain spacetime points. For instance, a world could be *chunky*, i.e., composed of minimal, extended spacetime tiles (perhaps no smaller than a Planck length). This view will be briefly discussed in passing, but our central concern in this paper is gunky spacetime.

[5] In particular, he writes "In the first place, such states [i.e., states that correspond to point values for continuous observables] cannot exist in the standard separable Hilbert space formulation. They can be introduced, but only at the expense of a prima facie less natural formulation of quantum particle mechanics. Moreover, exact value states for one observable imply undefined expectation values for many other observables. Indeed, it seems hard to make sense of the probabilities of the results of measurements of perfectly ordinary observables when one starts out, for example, in a position eigenstate" (p. 1457).

spacetime to be infinitely divisible and not pointy. In the case of matter, arguably, molecules are composed of certain atoms, which are composed of subatomic particles, and as Schaffer (2003) suggests, "We just don't know whether this chain stops" (p. 513). And the same is true of the spatiotemporal world; for all we know, spacetime might be gunky.[6] But if spacetime is gunky (and there are no instantaneous regions), then multilocational endurantism (one of the main contenders in the metaphysics of persistence) is false, since it's not the case that material objects are exactly located at multiple instantaneous regions of spacetime (since there aren't any).[7]

There are two natural responses to this argument. First, an endurantist might accept this argument and insist that her endurantist intuitions are definitely in tension with gunky spacetime. While I do not have anything like a knock-down argument against this thought, here is a worry. Suppose that physics eventually convinces us that spacetime is gunky: would the right response be to immediately endorse perdurantism or some other non-endurantist theory of persistence? It's not so obvious to me that this would be the correct response. So I suggest a second response to the above argument. I suggest that the endurantist seek out a new version of endurantism which retains the spirit of multilocational endurantism but which is neutral with respect to the mereological structure of spacetime. This neutrality, I take it, would be a clear advantage. The main goal of this paper is to provide such a view.

Our exploration begins with the following question: what would a multilocated enduring object look like in a spatiotemporally gunky world? In this paper, I sketch two plausible answers to this question by describing two types of persisting objects, both of which are arguably natural candidates for objects which endure through spatiotemporal gunk. I'll argue that a view which results from making one minor tweak to the standard formulation of multilocational endurantism correctly classifies the first possibility as a case of endurance. But then I'll sketch another plausible way in which an object might endure through spatiotemporal gunk and argue that this slightly tweaked view fails to classify the second possibility as a case of endurance. However, I'll argue that there is still hope for the package; I'll suggest a novel view which does in fact classify both cases as cases of endurance, as well as objects exactly located at multiple instantaneous regions of spacetime, should spacetime turn out to be pointy rather than gunky.

The paper has the following structure. In the second section, I briefly describe the standard characterization of multilocational endurantism. In the third section, I describe the first way in which an enduring material object might be multilocated in

[6] For more on gunky spacetime, see Arntzenius (2008), Chp. 4 of Arntzenius (2012), and Russell (2008).

[7] Strictly speaking, the thesis that spacetime is gunky does not entail the thesis that there are no instantaneous regions of spacetime. Arntzenius and Hawthorne (2005) make a similar point about spatial gunk: consider a spatial point P which is gunky but where each of its infinitely many proper parts are co-located with P. Similarly, consider a model with one instantaneous region of spacetime R which is gunky but where each of R's proper subregions are co-located with R. But for the purposes of this paper, let's ignore exotic models with co-located regions of spacetime. When I say gunk threatens multilocational endurantism, what I really mean is that the thesis that spacetime is gunky together with the thesis that there are no instantaneous regions entails the conclusion that multilocational endurantism is false.

gunk and then I offer the tweak. In the fourth section, I describe the second, problematic type of enduring object and highlight a number of analogous purely spatial cases which generate the same problem for multilocational endurantism. In the fifth section, I sketch the novel version of endurantism and argue that it makes all the right sorts of classifications.

2 Multilocational Endurantism

Roughly, multilocational endurantism is the view that enduring objects are exactly located at multiple instantaneous regions of spacetime. The view has been discussed in a number of places.[8] In what follows, I briefly describe what I take to be the standard characterization of the view.

We begin by introducing a relation of *exact location*. Though the relation is typically taken to be primitive, we can give the following intended meaning of the relation: say that an object o is exactly located at a region of spacetime R iff o is located at the spacetime region R which has the exact size and shape as o, and stands in all the same spatiotemporal relations as does o.[9]

Now for four crucial definitions. First, say that the *path* of a persisting object is the non-instantaneous region sketched out by the object's worldline on a spacetime diagram (or worldtube, if the object is spatially extended), i.e., it is the object's blueprint in spacetime. Sometimes this is taken as a primitive,[10] and sometimes it is defined in the following way: y is the path of x if and only if y is the mereological sum of the exact locations of x.[11] Second, we introduce the notion of a (spatially) *maximal* part of a path. Take one of my instantaneous exact locations, say, R. Proper subregions of R are also instantaneous; for example, a proper subregion R' of R which is an exact location of the upper top half of my body is also an instantaneous part of my path. Say that an instantaneous part x of a path P is *maximal* iff it is the intersection of the path and the set of all points which are simultaneous with the points composing x.[12] And now say that maximal non-

[8] Multilocational endurantism is defended/endorsed in van Inwagen (1990a, b), Gilmore (2007), Bittner et al. (2004) and Sattig (2006); it is discussed/explored in Hawthorne (2006, 2008), (2009) and (2014a), Donnelly (2010), Kleinschmidt (2011), Effingham (2012), Eagle (2016a, b); it is explored in the context of relativity theory in Balashov (2010, 2011), and Gilmore (2006); it is objected to or rejected in Gilmore (2006), Calosi (2010), Balashov (2011), Hofweber and Velleman (2011), and Costa (Forthcoming); and some replies and rejoinders appear in Gibson and Pooley (2006), Eagle (2010a, b), Gilmore (2010), and Rychter (2011).

[9] This gloss is taken from Gilmore (2007), though note that Gilmore calls this relation "exact occupation." See p. 179, n. 7. I take "exact location" to mean what Varzi (2007) means by "exact location," what Gilmore (2006) and Hudson (2001) mean by "exactly occupies," what Donnelly (2010) means by "is exactly located at," what Sattig (2006) means by "occupies," and what Hawthorne (2008) means by "is wholly located at."

[10] As in Effingham (2012).

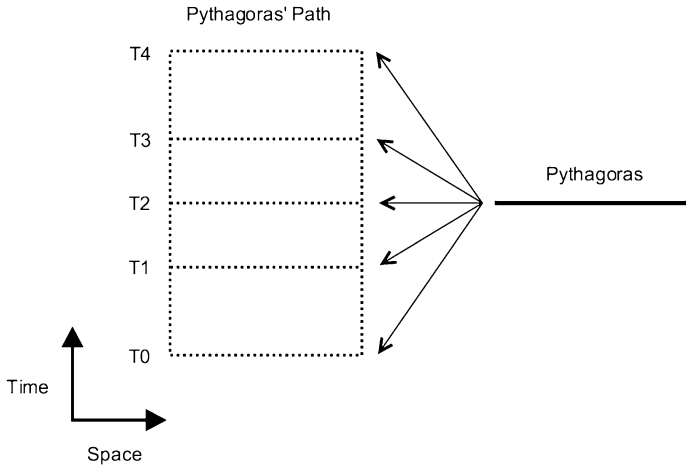
[11] As in Gilmore (2006). Moreover, the path of an object o corresponds to what Parsons (2007) calls the "exact location" of o, though, of course, this relation is *not* what multilocational endurantists mean to express by "exact location."

[12] Thanks to Jeff Russell for this way of putting it.

instantaneous parts of paths are fusions of maximal instantaneous parts of paths. Thus, R (one of my exact locations) is a maximal part of my path, but R' (one of my upper body's exact locations) is not a maximal part of my path. Third, let's say that an object *o endures through a region R* iff R is composed of instantaneous slices of spacetime and o is exactly located at every maximal instantaneous slice of R. And fourth, say that *o endures simpliciter* iff o endures throughout its entire path. Given these definitions, I take the standard characterization of multilocational endurantism to be:

(MULTILOCATION): Persisting objects endure simpliciter, i.e., are exactly located at every maximal instantaneous slice of their paths.

Though multilocational endurantists often deny that persisting objects have the proper temporal parts posited by the perdurantist, and though they often deny that persisting objects have the temporal extent posited by the perdurantist, the fundamental feature of endurance is cashed out in terms of *location*. Consider a case of an enduring material object, say, Pythagoras, who persists from t_0 to t_4.[13] A sketch of multilocational endurantism can be characterized by the following diagram.[14]



Pythagoras endures simpliciter; he is exactly located at t_1, t_2, t_3, and every maximal instantaneous slice of his path.

Though some have argued that the idea of multilocation is confused,[15] multilocational endurantists maintain with Gilmore (2007) that "there is nothing obviously false or unintelligible about the claim that a single thing exactly occupies each of several non-intersecting, extended regions but not their union or any of their proper subregions" (p. 179, n. 7). Multilocational endurantists typically reject the

[13] Apparently, Pythagoras' disciples credited him with the power of bi-location. See Kenny (1998), p. 2.

[14] This diagram is based on Diagram (a) in Balashov (2011), p. 15, and Figure 2 in Gilmore (2006), p. 205.

[15] In particular, Parsons (2007) and Hofweber and Velleman (2011).

common perdurantist idea that persisting material objects are exactly located at their paths (though they need not; this will be discussed in the next section). They also reject the endurantist idea developed in Parsons (2000, 2007) that persisting material objects are temporally simple albeit four-dimensional objects exactly located at four-dimensional regions of spacetime.[16]

But again, for all we know, the world might turn out to not have any instantaneous regions of spacetime. If there are no such regions, then multilocational endurantism must be false, since it entails that some objects are exactly located at instantaneous regions of spacetime.[17] There are a couple of plausible ways the spatiotemporal world might fail to be composed of instantaneous regions. First, the spatiotemporal world might be chunky, i.e., composed of spatiotemporal tiles and thus composed of temporal minima. Revising multilocational endurantism so that it classifies objects which endure through temporal minima as genuine enduring objects would be straightforward: we could simply add a clause to (MULTILOCATION) classifying objects which are exactly located at each of the

[16] The formulation of multilocational endurantism I provide is a little more precise than what is typically offered in the literature. But it's meant to rule out some cases which I would think multilocational endurantists would not want to classify as cases of endurance. I'll mention three. First, it rules out an enduring object o which is only exactly located at two spatially disjoint and yet simultaneous regions R and S. One might think that this *should*, however, count as a case of endurance and think of this case as an exotic case of time-travel. I'm inclined to think that since the object only ever exists at one "instant," it is more natural to think of this case as a case of instantaneous space-travel (rather than genuine time-travel), and thus not as a case of persistence (after all, a familiar intuitive slogan is: something persists iff it exists at more than one time). But if one disagrees, then one is free to drop the requirement that a persisting object needs a non-instantaneous path (with some fix to prevent a mono-located instantaneous object counting as an enduring object; also note that the third problem below would also need to be dealt with). Thanks to a referee for bringing up the idea of time-travel in this scenario. Second, it rules out an enduring object o which endures through some region R but then is also exactly located at a temporally extended region R' which is disjoint from R: o would endure through R but would *not* endure simpliciter. Third, there are models where (1) there are instantaneous regions *and* (2) all regions are gunky. In this sort of model, every instantaneous region has an instantaneous region as a proper part, i.e., we have a plenitude of coincident regions. (The analogous model demonstrating the consistency of gunky space and the existence of spatial points is discussed in Arntzenius and Hawthorne 2005). Suppose an object o was exactly located at one and only one "gunky instantaneous region." The requirement that a persisting object's path be non-instantaneous ensures us that an object which is multiply located at such a region is not in fact an enduring object.

I should note two further complications. First, suppose an object is exactly located at only two instantaneous regions of spacetime. Should this count as a case of endurance? I'm not sure what the multilocational endurantist would want to say about this case so I remain neutral in the formulation of the view, but if she wanted to not characterize this case as a case of endurance, perhaps she could simply place a further constraint on the definition of an object's path by requiring that it be continuous. Second, time-travel complicates things. Suppose that a brick is instantaneously created with the width of ten inches and endures for one minute. It then travels back through time in such a way to be adjacent to itself for another minute, and then is destroyed. The brick's path will be a four-dimensional region which is both one minute long and 20 inches wide, but there will be no maximal instantaneous 20 inch part of the path at which the brick is exactly located, and thus the brick doesn't endure simpliciter. While I should admit that the purpose of this paper is not to deal with every possible sort of *exotica*, to deal with this problem, we might say that an object o endures simpliciter iff for every maximal part P' of its path P, o is located at a subregion (proper or improper) of P'. However, I want to note in passing that these sorts of exotic time-travel cases won't be problematic for the novel view I'll propose near the end of the paper – the enduring time-traveling brick will correctly be classified as an enduring object.

[17] Assuming, of course, that at least some objects persist.

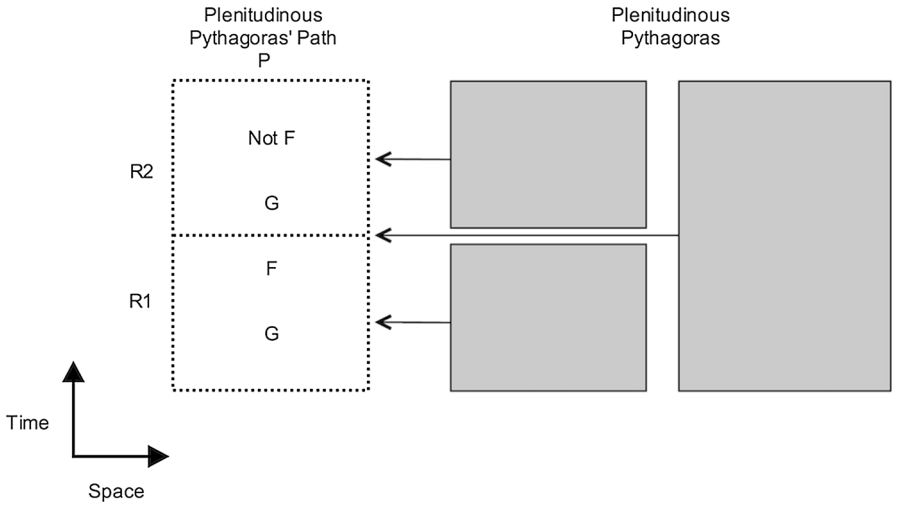
temporal minima of their paths as objects which endure simpliciter. The more pressing case, however, is the case where the world contains spatiotemporal gunk. In the remainder of the paper, I aim to show that the spirit of multilocational endurantism is perfectly consistent with material objects enduring through spatiotemporal gunk. For each of the two objects to be discussed, I will offer a few brief remarks for why they arguably ought to count as natural candidates of endurance. However, I want to admit up front that my goal is not to get entangled in a terminological dispute about what ought and ought not count as endurance. Rather, I want to take as a starting point my interpretation of the standard characterization of multilocational endurantism and then explore one way the world might mereologically differ from the pointy conception. I want to then offer what I take to be extremely plausible candidates of endurance in such a setting. So let's assume that the world is spatiotemporally gunky. What would it look like for an object to endure through gunk? Two possibilities come to mind.[18]

3 Plenitudinous Endurers

First, consider a spatiotemporally gunky possible world where persisting material objects are exactly located at every maximal (albeit non-instantaneous) part of their paths.[19] Pick any maximal part of the object's path (including the path itself), and it is exactly located there. Call these enduring entities *plenitudinous endurers*. To get a flavor of what these objects are like, consider a simple model where a plenitudinous endurer (call him Plenitudinous Pythagoras) persists for two minutes and then is annihilated.

[18] Other versions of endurantism seem to handle spatiotemporal gunk just fine. First, consider the mereological version of endurantism developed in Parsons (2000, 2007) (it's worth noting that not all endurantists find this version of persistence to be a clear version of endurantism, since one might be worried that on this view, it's not obvious that objects are wholly present at every time at which they exist). The view is called *terdurantism* by Miller (2009), *transdurantism* by Daniels (2014), and *pardurantism* by Effingham (2012). On this view, enduring objects are four dimensional temporally extended simples. For such an object o, the exact location of o is some four-dimensional region of spacetime. But if spacetime is gunky, then o's exact location is gunky, and o endures through time by being wholly present at a (albeit gunky) four-dimensional region of spacetime. A very interesting and similar version of endurantism (albeit a supersubstantivalist version) is explored in Nolan (2014). On a second endurantist package, sketched in Hawthorne (2008) and recently developed in Hofweber and Velleman (2011), say that an object is *wholly located* at a region of spacetime just in case it is intrinsic to how things are at that region that that very object exists at that region. And to say that a material object is wholly located at each time at which it exists amounts to saying, as Hawthorne notes, that "God could recognize me as present at any given time that I exist just by considering the world at that time, as it is in itself" (p. 276). If the world is in fact temporally gunky, then this package suggests that an object o enduring through time, say $t_0 - t_n$, amounts to God being able to look at any interval d in $t_0 - t_n$ and see that o is present, just based on the intrinsic nature of d itself.

[19] It's important to note that we now cannot take 'maximal part' as defined in the previous section. Here is one way of defining it in the present context. Supposing there is a temporal partial ordering on gunky regions: a part p of a path P is *maximal* iff it is the intersection of P with that region S which is the fusion of all regions s such that none of s is strictly earlier than any of p, and none of s is strictly later than any of p. Thanks to an anonymous referee for this definition.



During the first minute, he is both *F* and *G*. And during the second minute, he is *G* but no longer *F*. Call the part of the path corresponding to the first minute R_1, the part of the path corresponding to the second minute R_2, and the path *P*. According to our first possibility, Plenitudinous Pythagoras is multiply located at spacetime regions *P*, R_1, R_2, and each of the infinitely many maximal parts of *P*.[20]

Why think that plenitudinous endurers in gunky spacetime are candidates of endurance? Before answering this question, it is worth thinking about the question in the context of pointy spacetime. As I mentioned in the beginning of the paper, formulations of multilocational endurantism in the literature assume that objects are only located at *instantaneous* regions of spacetime. But it's worth noting that they need not. After all, Peter van Inwagen, naturally interpreted as one of the early pioneers of multilocational endurantism, seems to think that objects are located at instantaneous regions *and* every maximal part of their paths. He writes of Descartes that he occupied regions with zero temporal extent, but also a region

> *R* which has a temporal extent of fifty-four years - and, presumably, that he occupies regions having extents whose measures in years correspond to every real number between 0 and 54. Therefore, in his view [i.e., the view van Inwagen ultimately adopts] Descartes did not have a unique temporal extent. That is to say, he didn't have a unique temporal extent at all; the concept of a temporal extent does not apply to Descartes or to any other object that persists or endures or exhibits identity across time. Thus, in saying that the philosopher

[20] And for the endurantist who thinks that plenitudinous endurers are possible, the standard responses to the problem of temporary intrinsics are available. She could, for instance, relativize properties to spatiotemporal regions and thus say that Plenitudinous Pythagoras is *F* at R_1 but not R_2. Or she could accept some form of adverbialism and say that Plenitudinous Pythagoras is *F* R_1-ly though not R_2-ly. Or she could tense the copula: Plenitudinous Pythagoras is-at-R_1 *F* though is-not-at-R_2 F. Of course, enduring objects can gain and lose parts, so it follows that such objects have different sizes and shapes at different regions.

> who was hungry at t_1 was a three-dimensional object, the 'Threeist' [i.e., van Inwagen's endurantist] means that he had a greater-than-zero extent in each of the three spatial dimensions - and that's all. (van Inwagen 1990a, p. 252)

So it's worth noting that the endurantist need not assume that objects are *only* located at the maximal instantaneous parts of their paths; there's at least an option in logical space for her to think that enduring objects in pointy spacetime are plenitudinous in the way suggested by van Inwagen (though perhaps there are some reasons to deny this in the context of pointy space). Given that this early formulation of multilocational endurantism seems to count plenitudinous endurers as enduring objects, plenitudinous endurers in gunky spacetime seem to be natural candidates of endurance. There are also a couple of additional reasons for thinking that plenitudinous endurers are natural candidates of endurance. First, it's worth noting that they fail to have any proper temporal parts. Second, though they surely aren't three-dimensional, it's worth noting that they fail to have a *unique* temporal extent (in line with van Inwagen's Descartes); they have spatiotemporal extent *relative* to particular regions of spacetime.

As it turns out, with one small tweak, a view very similar to multilocational endurantism characterizes these objects as enduring objects (in both the pointy and gunky contexts). The intuitive idea is to no longer require objects to be multiply-located at *instantaneous* regions of spacetime and yet to be massively multilocated in the right sort of way. Let's say that an object *o endures through a region R* iff for any maximal non-instantaneous part R' of the region R, there are parts r_1 and r_2 of R', such that r_1 and r_2 are maximal and disjoint, and o is exactly located at both r_1 and r_2. And again, an object endures simpliciter iff it endures throughout its entire path. With this minor tweak in our definition of *enduring throughout a region*, we have a new view of endurance according to which:

> (MULTILOCATION*): Persisting objects endure simpliciter, i.e., for every maximal non-instantaneous part P' of their path, they are located at maximal disjoint parts of P'.

Requiring an enduring object to be located at such maximal *disjoint* parts rules out objects which aren't multilocated enough: suppose an object o's path is (intuitively) 100 years long and that o is located at its path, but then only at two maximal proper parts of its path (corresponding to, say, the first and second halves of its life). Intuitively, this object doesn't endure in the locational sense; and the 'disjoint parts' requirement assures us of this. You might be worried that (MULTILOCATION*) fails to capture the idea behind multilocational endurantism. But the formulation does, I think, capture the view: it is one way of capturing the idea that enduring objects are massively multilocated throughout their paths, which is arguably the central idea behind multilocational endurantism.

Plenitudinous Pythagoras, however, is exactly located at maximal disjoint parts of every maximal non-instantaneous part of his path. And so according to our slightly revised characterization of multilocational endurantism, he counts as an enduring object.[21] Moreover, our slightly revised view also classifies objects which

[21] Plenitudinous endurers are inconsistent with a principle of mereological harmony (on mereological harmony, see Varzi 2007; Uzquiano 2011; Saucedo 2011; Leonard 2016): x is a proper part of y iff x's

are multiply located at instantaneous regions of spacetime as enduring objects (in line with the original characterization of multilocational endurantism). Suppose an object o^* is multiply located at every maximal instantaneous slice of its path P. Take any maximal non-instantaneous part P' of P, and o^* is exactly located at disjoint (albeit instantaneous) parts of P'. And so (MULTILOCATION*) nicely classifies objects which are multiply located at instantaneous regions of spacetime as enduring objects. Moreover, if one thinks with van Inwagen that enduring objects are plenitudinous in the pointy setting, such objects are also characterized as enduring objects.[22]

So a view very much like multilocational endurantism is not immediately threatened if the world turns out to contain both spatiotemporal gunk and plenitudinous endurers. However, there is a second possibility which causes trouble for both (MULTILOCATION) and (MULTILOCATION*).

4 Thin Endurers

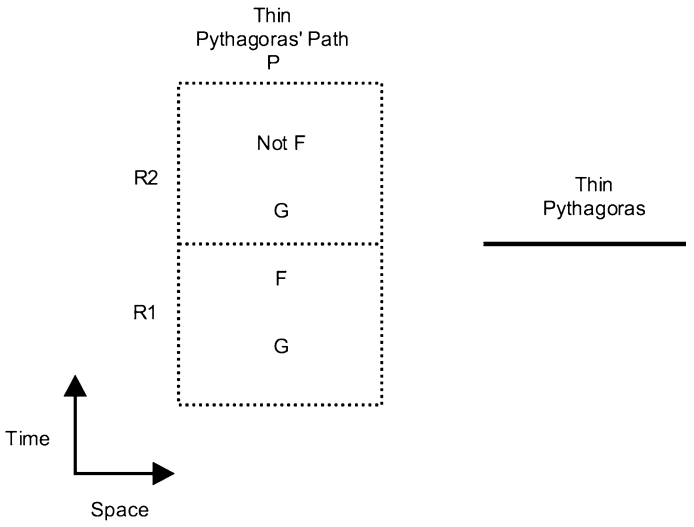
Consider a spatiotemporally gunky possible world where material objects persist even though they fail to be exactly located at any regions of spacetime. This is a picture on which material objects are *thinner* than regions of spacetime; material objects are (temporally) unextended objects which persist through spatiotemporal gunk. Call these enduring entities *thin endurers*.

Footnote 21 continued
exact location is a proper part of y's exact location. Since Plenitudinous Pythagoras is exactly located at both R_1 and P, and since R_1 is a proper part of P, it follows from our principle of harmony that Plenitudinous Pythagoras is a proper part of himself, which is absurd. Some might take this as a reason to think that plenitudinous endurers are impossible. However, the second type of object which endures through spatiotemporal gunk (sketched in the subsequent section) does not violate these sorts of harmony principles.

[22] Are there objects which are not plenitudinous endurers, but close? And if so, should they count as cases of endurance? Here are two types of examples (one which counts given (MULTILOCATION*), and one which might or might not). First, suppose an object o_1 is exactly located at some spacetime region R and also every closed subregion of R (though not the open ones). Or similarly, suppose an object o_2 is exactly located at some spacetime region R and also every subregion of R with a rational temporal length (but not an irrational temporal length). Though there will be tons of gaps (for instance, o won't be exactly located at maximal parts of its path with irrational temporal lengths), and though o_1 and o_2 are not strictly speaking plenitudinous endurers, they nonetheless endure simpliciter, since they are exactly located at maximal disjoint parts of every maximal non-instantaneous part of their paths. A second case was suggested by an anonymous referee. Say that a region is *homogenous* iff it is qualitatively uniform. Now say that a region is *homo-maximal* iff it is homogeneous and is not a part of any homogeneous region. Now consider an object that is exactly located at every maximal homo-maximal part of its path. With this model, we can look at the pattern of qualitative variation over an object's path, find the slices that correspond to qualitative change, and then locate the object at just those regions which are bounded by qualitative changes but are qualitatively homogenous internally. Given the above definition, so long as these objects are located at maximal disjoint parts of every maximal non-instantaneous part of their paths, they count as enduring objects. However, this is not guaranteed: consider a little model where an object is red for a year and then green for a year (and that's it). This object will be located at a region corresponding to the first year, though no maximal proper subregions of that region, and thus by (MULTILOCATION*), will not count as a case of endurance.

Here is an analogy. Suppose that space is gunky and that material objects are composed of zero-dimensional material continua. Imagine that we had a one meter long, one dimensional gunky line of space, the end of which connected to the (zero-dimensional) bullseye of the surface of a target. And suppose we had a fancy gun which could shoot zero-dimensional point sized bullets. Suppose that we perfectly lined up the gun with the one meter long line of gunky space and pulled the trigger: the point sized object traverses the line and hits the bullseye. The moving point sized bullet is perfectly analogous to a thin endurer and the gunky one-dimensional line is perfectly analogous to four-dimensional gunky spacetime. Informally: if there *were* instantaneous regions of spacetime, that's where thin endurers would be located.

We can use the relationship between weak and exact location to make the picture even clearer. Following Parsons (2007), say that an object o is *weakly located* at a region R iff R is not completely free of o. At any time between the event of the trigger being pulled and the event of the bullet hitting the bullseye, the point is not exactly located anywhere; however, there will be a number of (extended) one-dimensional subregions of the line at which the point is weakly located. Likewise, take the path through which a thin endurer persists, and note that though the object isn't exactly located anywhere, there will be a number of extended four-dimensional subregions of the path at which the material object is weakly located. The following diagram represents a model (analogous to the model in the previous section) whereby a thin endurer, call him Thin Pythagoras, persists through his path P.



Though he is not ever exactly located anywhere in P, he is both F and G throughout R_1, G though not F throughout R_2, and is G throughout P.[23]

[23] A natural idea would be to treat thin endurers just like plenitudinous endurers, with respect to the problem of temporary intrinsics. Relationalism, adverbialism, and copula-tensing seem to all be live options for how to model a thin endurer which changes its properties over time.

Thin endurers are arguably quite natural candidates for endurance. Like plenitudinous endurers, thin endurers both fail to have any proper temporal parts and fail to have a unique temporal extent (in fact, they have *no* temporal extent). The pressing question is not 'Are thin endurers really enduring objects?', but rather, 'Are thin endurers even possible? Aren't they strange?' In response, it is worth noting that thin endurers fall within a broader class of objects which are alleged counterexamples to a theorem of Parsons' (2007) theory of location:

(EXACTNESS): If x is weakly located somewhere, then x is exactly located somewhere.

But (as Parsons himself notes) this is a contentious thesis. Forget for the moment about thin endurers; there have been a number of purely *spatial* cases proposed as counterexamples to (EXACTNESS). I'll briefly mention three.[24] The first, which was raised by Cody Gilmore, is the spatial analogue to a thin endurer: suppose that space is gunky and that there is a point sized material object o. While o might be weakly located in a number of regions, it might not have an exact location.[25] Second, suppose that space is junky, i.e., every region has a proper superregion, and that an *omnipresent* object t completely fills in every region. While t is weakly located everywhere, it doesn't seem to have an exact location. Third, a case initially from Nolan (2006), but which was proposed as a counterexample to (EXACTNESS) by Shieva Kleinschmidt: suppose water and wine are gunky and that they are mixed in gunky space so that any portion of the blend (no matter how small) contains both water and wine. Nolan has argued that on one interpretation of this *stoic blend*, the water and wine might fail to be exactly located anywhere.[26] So why think that thin endurers are possible? One reason is that thin endurers (though strange) seem conceivable, and thus prima facie metaphysically possible. But more importantly, given that there is a broader class of objects which philosophers have taken to be counterexamples to (EXACTNESS), it is plausible to think that thin endurers ought to fall in the same category. The only reason (I can think of) for wanting to deny that they are possible is that they are counterexamples to (EXACTNESS). But given that a number of philosophers have independent reasons to deny (EXACTNESS), there are at least some philosophers who will likely think that thin endurers are possible.

Not only does multilocational endurantism fail to classify the thin endurer as an enduring object, it also immediately fails to classify the material point, the spatially omnipresent object, and the water and wine as enduring objects, simply because they lack *spatial* locations (in particular, both (MULTILOCATION) and (MULTILOCATION*) fail to classify the objects as such). But why would lacking a spatial location be relevant for whether or not something endures? I suggest that the standard characterization of multilocational endurantism is too demanding. It would be worthwhile to have a formulation of endurantism which does not immediately rule

[24] And each of which is discussed in Section 3 of Parsons (2007).

[25] See Parsons (2007), f.n. 4.

[26] Again, see Parsons (2007), f.n. 4; though see Leonard (2014) for why this case is a bit more complicated than the other examples mentioned above.

out these objects as enduring objects, simply given the fact that they lack exact locations. We need a broader conception of endurance.

5 Whiteheadian Multilocation

Thin endurers are problematic for multilocational endurantism because they endure and yet aren't exactly located anywhere. Many endurantists argue that characterizing endurantism in locative terms (what Costa (Forthcoming) calls *the locative turn*) has been a step in the right direction; and I agree. However, rather than characterize the view in terms of exact location, I suggest that we characterize the view in terms of a new locative primitive. This final section will be structured in the following way. First, I will informally describe the primitive. Second, to further elucidate the intended meaning of the primitive, I will argue that it is distinct from and cannot be defined in terms of some similar relations defined by Josh Parsons and Antony Eagle. Third, I will offer the new formulation of endurantism. I will then argue that it makes all the right sorts of classifications and that similar formulations of endurantism, spelled out in terms of similar relations from Parsons and Eagle, are problematic and thus that the new primitive is genuinely required.

I begin by introducing a primitive relation which I will call *containment*. Here's a little story to convey the intended meaning of this primitive. Suppose that Pythagoras is exactly located at both the North Pole and the South Pole, though at the South Pole he only has nine fingers (whereas at the North Pole, he has all ten). Now consider two disjoint spherical regions, one near the North Pole (call it *R*-North) and one near the South Pole (call it *R*-South), both of which are slightly larger than Pythagoras. Moreover, Pythagoras is located inside both *R*-North and *R*-South. First-pass characterization of the primitive: Pythagoras is *contained* in both *R*-North and *R*-South.

I will now argue that containment is distinct from two similar relations found in Parsons (2007). Say that *o* is *entirely located* at *R* iff *o* is weakly located at *R* and that everywhere disjoint from *R* is free of *o* (i.e., informally, *o* is in *R* and *o* is not anywhere outside of *R*). And now say that *o* is *wholly located* at *R* iff every part of *o* is weakly located at *R* (i.e., informally, none of *o* is missing from *R*). As Parsons notes, these two relations tend to go around together.[27] However, containment is distinct from both. Pythagoras is not entirely located in *R*-North (because there is a region disjoint from *R*-North that *isn't* completely free of Pythagoras, i.e., *R*-South). Moreover, Pythagoras is not wholly located in *R*-South (since he has a part, i.e., a finger, which is missing from *R*-South). Though not entirely located nor wholly located in both *R*-North and *R*-South, Pythagoras is *contained* in both.

You might be tempted to claim that containment, if coherent at all, is really just equivalent to whole location relativized in an appropriate (temporal or spatiotemporal) way. After all, you might think, if parthood is two-place and eternal, then Pythagoras is

[27] Parsons (2007) notes, however, that an extended simple hovering over the sill of my window would be neither entirely in my office nor entirely in the street, though it would be wholly in my office and wholly in the street. See p. 212.

clearly not contained in *R*-South, since one of his parts (i.e., a finger) is not there; he is no more contained in *R*-South than he is contained in the lower half of *R*-South. Moreover, given the familiar problem of temporary intrinsics, you might think that endurantists are already forced to temporally or spatiotemporally relativize parthood; so why not simply define containment in the following way: *x* is contained in *R* iff all of *x*'s parts at *R* are weakly located at *R*? What's the difference between containment and (relativized) whole-location?[28] But this is a temptation we must resist. For the perdurantist will also admit that all of Pythagoras' parts at *R*-North are weakly located at *R*-North. This proposal of temporal (or spatiotemporal) relativization of whole-location makes the relation utterly trivial. In fact, this problem should sound familiar to the endurantist, for this is the exact problem Sider (2001) raised against the endurantist. In fact, this is one of the early problems that led to a locative characterization of endurance; Sattig, for instance, responds to this problem by suggesting that "[t]he way forward for the endurantist is to give an account of the nature of persistence at the level of spacetime and to rest content with this account" (p. 61). For the same reason, we should not give in to the temptation to define containment in terms of relativized whole location.[29]

Next, it is important to distinguish containment from the relation of *whole containment* defined in Eagle (2016b). Say that *o* is *wholly contained* in *R* iff *o* is located at a sub-region of *R*. I mention this relation not just to distinguish it from my own, but also because it is closer to the intended meaning of my primitive than the relations defined by Parsons. There is one important difference in meaning between my notion of containment and Eagle's. This can be quickly seen with a variant of the North Pole story: suppose that space is gunky, and that Pythagoras is swapped out for a zero-dimensional material point (which, like Pythagoras did, hovers somewhere near both the North Pole and the South Pole at the same time). The point isn't located anywhere, and hence isn't wholly contained (in Eagle's sense) in *R*-North or *R*-South. But there is a sense in which the point *is* contained in both *R*-North and *R*-South, and my primitive allows for this.[30] So, like Eagle's whole containment, a sufficient condition of *o* being contained (in my sense) in *R* is being located at a subregion of *R*; however, this is not a necessary condition (since something can be contained in a larger region even if that thing lacks an exact location). Hopefully this gives the reader a sense of the intended meaning of this primitive.[31]

[28] Thanks to both an anonymous referee and Dean Zimmerman for pushing me on this point.

[29] As pointed out by an anonymous referee, note we can avoid this problem if we treat all objects as mereologically simple (and if we deny DAUP and related principles), and if we reduce mereological variation to qualitative variation. Then, Pythagoras would be wholly located at R-North and wholly located at R-South, and instantiate the qualitative property 'being 10-fingered' at R-North, and the qualitative property 'being 9-fingered' at R-South. This, however, is not likely a view many endurantists will go for and thus I suggest that we really need a primitive containment relation for the formulation of endurantism.

[30] Elsewhere, Eagle (2010a) says that *o* is *contained* in *R* iff all of *o*'s parts are located at subregions of *R*. This too is distinct from my containment primitive, since according to my primitive, an object can be contained in a region and not be exactly located anywhere.

[31] If the reader remains skeptical about the meaning of the primitive, the central claim of the paper can be read as a conditional: if one understands the primitive, then the paper explores what can be done with it.

We are now in a position to state the new formulation of endurantism. Say that an object *o endures through a region R* iff *o* is contained in every maximal part of *R*. And again, an object endures simpliciter iff it endures through its entire path.[32] I suggest that endurantism be characterized in the following way:

(WHITEHEADIAN MULTILOCATION): Persisting objects endure simpliciter, i.e., are contained in every maximal part of their paths.

To see that the view retains the spirit of the standard characterization, note that we can construct a Whiteheadian relation which mimics the relation of exact location, in just the familiar way that Whiteheadian points mimic spatial points.[33] Consider a one-dimensional gunky line, i.e., a line composed of no points, but ever decreasing (and extended) sub-intervals of the line. We can construct points on this gunky line by taking an arbitrary interval of the line *d*, and by taking a set of converging sub-intervals of *d*. And though the line is in fact gunky, we can construct *Whiteheadian points* on the line by taking sets of converging sub-intervals of the line. In the same way, we can construct instantaneous regions in spatiotemporal gunk. Let's say that a *Whiteheadian time* is a set of temporally converging regions of spacetime.[34] We can then say that an object *o* is *located** at a Whiteheadian time *t* iff for every region $t' \in t$, *o* is contained in t', i.e., *o* is contained in each region of the temporally converging Whiteheadian time *t*. Now say that an object *o endures through a region R* iff *o* is located* at every maximal Whiteheadian time in *R*. And again, to *endure simpliciter* is to endure through your entire path. So persisting objects are ones which are located* at every maximal Whiteheadian time in their paths. This captures the spirit of multilocational endurantism, without requiring enduring objects to have exact locations.

There are two goals in the remainder of the paper. First, I will briefly show that (WHITEHEADIAN MULTILOCATION) correctly classifies thin and plenitudinous endurers as endurers (as well as objects exactly located at instantaneous regions in pointy spacetime). And second, I will argue that *containment* is necessary for (WHITEHEADIAN MULTILOCATION); it won't do to formulate the view in terms of other familiar locative relations.

First, (WHITEHEADIAN MULTILOCATION) generates the right verdicts concerning the cases raised above. For instance, even though a thin endurer fails to be exactly located at any part of its path, it nonetheless is contained in every maximal part of

Footnote 31 continued
Moreover, it would be interesting to construct a logic of containment and explore exactly how containment relates to other notions of location. However, once we allow for the possibility of multilocation, a number of similar location relations become quite difficult to define. I'll leave developing a logic of containment for an independent project.

[32] In the first section of the paper, I noted that sometimes 'path' is taken as a primitive and sometimes it is defined as the fusion of an object's exact locations. But given that we are taking seriously the possibility of states of affairs where objects lack exact locations, we cannot define it in terms of exact location. So instead, I'll officially take it as a primitive.

[33] At least in the context of gunky space, though not discrete space.

[34] Of course, not *every* set of converging sub-intervals converges on a point. The best way of mathematically characterizing Whiteheadian points (and thus Whiteheadian times) is not important for our purposes, but see Roeper (1997) for some details.

its path, and thus is contained in every member of every maximal Whiteheadian time of its path. Thus, it counts as an enduring object. Moreover, since a plenitudinous endurer is contained in every maximal part of its path, and thus is contained in every member of every maximal Whiteheadian time of its path, it too is classified as an enduring object. Furthermore, suppose spacetime is pointy and enduring objects are exactly located at multiple instantaneous regions. An object which is exactly located at all of the maximal instantaneous regions of its path is also contained in every maximal part of its path (given that being located at *R* is a sufficient condition for being contained in *R*), and thus is contained in every member of every maximal Whiteheadian time of its path. And so an object exactly located at all of the maximal instantaneous regions of its path is correctly classified as an enduring object.

Second, why not formulate (Whiteheadian Multilocation) in terms of more familiar relations already introduced in the literature? Why the need to introduce a new primitive? I'll argue that formulating the view in terms of Parsons' entire, whole, or weak location is unsuccessful. First, we cannot say that an object *o* endures simpliciter iff *o* is *entirely located* in every maximal part of its path (where, again, an object *o* is entirely located in a region *R* just in case it's weakly located there and everywhere disjoint from *R* is free of *o*). To see this, consider a plenitudinous endurer *o* exactly located at its four-dimensional path *P*, as well as every maximal part of *P*. Consider a maximal proper subregion of *P*, say *R*, (and thus a region at which *o* is exactly located). It's not the case that *o* is entirely located at *R*, since everywhere disjoint from *R* is *not* free of *o* - the part of the path disjoint from *R* is *not* free of *o*, since *o* is located at *P*.

Moreover, we cannot say that an object *o* endures simpliciter iff *o* is *wholly located* at every maximal part of *o*'s path (where, again, an object *o* is wholly located in a region *R* just in case none of *o* is missing from *R*). If we did, then enduring objects would not be able to gain and lose parts, which is something the endurantist will surely not want to accept. (Nor should we define the notion in terms of relativized whole-location, given the worry I raised earlier).

Moreover, we cannot say that an object *o* endures simpliciter iff *o* is *weakly located* at every maximal part of *o*'s path (where, again, an object *o* is weakly located in a region *R* just in case *R* isn't completely free of *o*). At first glance, this account seems to make a number of correct classifications. This account of multilocational endurantism entails that thin endurers are enduring objects. Even though thin endurers have no exact locations, they are weakly located at each maximal part of their paths. This account also entails that plenitudinous endurers count as enduring objects. Though plenitudinous endurers are exactly located at infinitely many regions (unlike thin endurers), they are also weakly located at every maximal part of their paths, and thus count as enduring objects. Moreover, it's important to mention that even if the world turns out to contain pointy spacetime, and enduring objects like tables and chairs are exactly located at multiple instantaneous regions of spacetime, they are also weakly located at every maximal part of their paths (where for any maximal Whiteheadian time *t* in the object's path, the members of *t* converge to an exact location of the enduring object). Thus, this characterization correctly entails that such objects endure.

However, this strategy is too liberal; it classifies as endurers some objects which, by the multilocational endurantist's standards, are clearly not endurers. First, perduring objects would be classified as enduring objects, since they too are weakly located at every maximal part of their paths. Second, mono-located temporally extended simples, i.e., "enduring" objects as described by Parsons (2000, 2007), would count as enduring objects on this present approach.[35] It's also worth briefly mentioning that we obviously cannot formulate the view with Eagle's relation of whole containment, since being wholly contained in a region requires having an exact location (which is something the thin endurer does not have). For these reasons, I propose defining (Whiteheadian Multilocation) in terms of the primitive notion of containment sketched and developed at the beginning of this section.

6 Conclusion

We have seen that one of the more popular endurantist packages on the market assumes that there are instantaneous regions of spacetime, and that all enduring objects have exact locations. But these are controversial philosophical theses. So I suggest that the standard characterization of multilocational endurantism is too strong.

The spirit of multilocational endurantism, however, can be salvaged by adopting (Whiteheadian Multilocation). This package doesn't assume that spacetime is pointy, nor does it assume that enduring objects all have exact locations. Moreover, (Whiteheadian Multilocation) entails that plenitudinous endurers and thin endurers are in fact both enduring objects. It also entails that (should the world turn out to contain pointy spacetime) objects which are exactly located at multiple instantaneous regions of spacetime count as enduring objects. Given that the standard characterization of multilocational endurantism generates the wrong verdicts for a number of these plausible cases of endurance, I suggest that those

[35] Though there are a number of ways of trying to make this option work, it nonetheless comes with undesirable results. I'll first mention some ways of trying to make this option work, and then mention a problem. First, though multilocational endurantists maintain that the fundamental feature of endurantism concerns location, they typically reject the existence of material objects which have proper temporal parts. And thus, on mereological grounds, the defender of the current option could deny that objects with proper temporal parts endure simpliciter (by insisting that no objects with proper temporal parts actually exist). Second, one might be interested in positing certain bridge principles governing the relationship between weak location and exact location. Here is a principle which would be very natural for the multilocational endurantist to accept:

> (Weak-Exactness): If an object o is weakly located at every member of a Whiteheadian time t, and there exists an instantaneous region of spacetime R such that t converges to R, then o is exactly located at R.

This principle, though a bit brute, suggests that if the world turns out to contain instantaneous regions of spacetime, mono-located temporally extended simples are metaphysically impossible. However, a related worry remains. Temporally extended simples located in temporal gunk remain classified as enduring objects on the present approach (since (Weak-Exactness) doesn't entail that these types of objects are metaphysically impossible) and this, I take it, is an undesirable classification for the multilocational endurantist.

sympathetic to multilocational endurantism should opt for (WHITEHEADIAN MULTILOCATION).[36]

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