# Chapter 1
# Building Enduring Objects Out of Spacetime

**Cody Gilmore**

Endurantism, the view that material objects are wholly present at each moment of their careers, is under threat from supersubstantivalism, the view that material objects are identical to spacetime regions. I discuss three compromise positions. They are alike in that they all take material objects to be composed of spacetime points or regions without being identical to any such point or region. They differ in whether they permit multilocation and in whether they generate cases of mereologically coincident entities.

## 1.1 Introduction

Let me start with a rough characterization of two main views about persistence:

**Endurantism.** At least some material objects persist through time; and every material object is temporally unextended and wholly present at each instant at which it exists at all. Moreover, it is not the case that every material object has a different instantaneous temporal part[1] at each different instant at which it exists.

[1]The standard definition of 'instantaneous temporal part' runs as follows: 'x is an instantaneous temporal part of y at t' means '(i) t is an instant, (ii) x is a part of y at t, (iii) x overlaps-at-t every part-at-t of y, (iii) x is present at t, and (iv) x is not present at any other instant'. (This is based on Sider 2001, 59.) For other definitions, see Gibson and Pooley (2006, 163), Parsons (2007), and Balashov (2010, 73). The key point is that, in order for a thing y to count as a temporal part of a thing x, y must be a part of x and y must be *spatially co-located* with x at any moment at which y is present.

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**Perdurantism.** At least some material objects persist through time; every material object has a different instantaneous temporal part at each different instant at which it exists. Material objects that do persist are temporally extended and are at most partially present (not wholly present) at any one instant.

I will introduce more carefully formulated views later on (from Gilmore 2006), but these are adequate for present purposes. Endurantism fits comfortably with presentism and certain other A-theories of time.[2] It also fits together fairly well with a certain brand of B-theoretic eternalism. What I have in mind here is a view like Newton's, according to which substantival space and substantival time are two separate and fundamental entities, and spacetime, if there is such a thing at all, is merely a construct of some sort. (Perhaps spacetime points are identified with ordered <point of space, instant of time> pairs.) Call this view about space and time 'separatist substantivalism'; it should be understood as incorporating eternalism and the B-theory.

But eternalist, B-theoretic endurantism begins to run into trouble as soon as we shift to (i) *relationism* about time or to (ii) a *spacetime* framework, be it substantivalist or relationist. Start with (i). Given eternalism and the B-theory, endurantists face pressure to invoke times or spacetime regions to handle the problem of change.

Suppose that Bob changes from being bent (an hour ago) to being straight (now). If perdurantism is true and Bob has temporal parts, then we can say that it was one temporal part of Bob that was bent and it is a different temporal part of Bob that is straight. If the A-theory is true and there is a metaphysically privileged time, then we can say that Bob himself is straight, not bent (though he was bent). Without temporal parts or a privileged present, however, the most natural account of change is to 'relativize to times': say that Bob is bent at one time (or spacetime region) and straight at another.[3] The idea is that Bob's shapes are really relations: he bears the bent-at relation to one time (or region) and the straight-at relation to another. If, as the relationist claims, there are no such things as times or regions, then this account fails, and it is unclear what else endurantist can put in its place.[4] I will assume, then, that if endurantism is going to find a home in an eternalist, B-theoretic world, such a world will need to include substantival times or spacetime regions. Now consider (ii). Is eternalistic, B-theoretic endurantism tenable in the spacetime framework? By 'the spacetime framework', I mean, roughly, the view that the spatiotemporal is more fundamental than the purely spatial or the purely temporal. Given the spacetime framework, we have a choice between spacetime relationism

[2] A-theories of time all say that there is a time that is present in some absolute, not-merely-indexical sense. That is, they say that there is a 'metaphysically privileged' present time. The B-theory of time denies this. Presentism is an A-theory of time according to which there are no non-present entities (such as, presumably, pre-Socratic philosophers and Martian outposts). Eternalism is the view that the past, present, and future all exist equally. See Sider (2001) and Markosian (2010) for more on these views.

[3] See Haslanger (2003) for an overview of these issues.

[4] See Hawthorne and Sider (2006) for a sophisticated discussion of this issue.

and spacetime substantivalism. Spacetime relationism, according to which there are objects and/or events standing in spatiotemporal relations but there are no spacetime points or regions, is inhospitable to endurantism for reasons that I have just sketched. So we can focus on the substantivalist version of the spacetime framework, which I state as follows:

**Spacetime Substantivalism.** Spacetime is more fundamental than space or time. There are such things as concrete, substantival spacetime points and/or regions. If there are such things as points or regions of space, these are merely spacetime regions of certain sorts ('columns'). Likewise, if there are such things as instants or intervals of time, these are merely spacetime regions of certain other sorts ('rows').

The view is neutral as to whether spacetime is relativistic. The question we now face is this: how is endurantism affected by the transition from *separatist* substantivalism to *spacetime* substantivalism, be it pre-relativistic or relativistic? (As with separatist substantivalism, I will understand spacetime substantivalism as incorporating eternalism and the B-theory.) Sider (2001) and Schaffer (2009) both argue that endurantism is harmed by this transition. Their argument runs through two claims:

(1) If spacetime substantivalism is true, then so is supersubstantivalism, the view that each material object just is a spacetime region. (They appeal to considerations of parsimony and, in Schaffer's case, fit with physics; more on this in Sect. 1.2.)
(2) If supersubstantivalism is true then perdurantism, not endurantism, is true. (Persisting spacetime regions perdure; they don't endure.)

No analogous argument is available given separatist substantivalism. In particular, separatists have no analogue of premise (1). For they have no locations with which material objects can be plausibly identified.[5] However, as soon as one makes the shift from separatist substantivalism to spacetime substantivalism, one gains the option of identifying material objects with locations (spacetime regions), and with that option available, parsimony (among other things) counts heavily in favor of taking it.

The argument carries real weight. In light of it, there's no denying that the transition from separatist substantivalism to spacetime substantivalism does some harm to endurantism. Still, it's worth asking: if one insists on combining spacetime

[5]They can't identify an object with its location in space, since objects often occupy different regions of space at different times, but no region of space occupies different regions at different times. And of course they can't identify an object with its location in *time* – say, the interval that is the object's total timespan. There are many reasons for this, but one of them is that, again, an object typically occupies different regions of space at different times, but no interval of time does this. Finally, they can't identify a material object with a spacetime region, since they either reject spacetime regions altogether or treat them as set-theoretic constructs; and presumably material objects are not set-theoretic constructs. The shift from space and time to spacetime solves these problems. No region of space is in different places at different times, but there are regions of spacetime that are. And spacetime substantivalists are free to deny that *spacetime* regions are set-theoretic constructs.

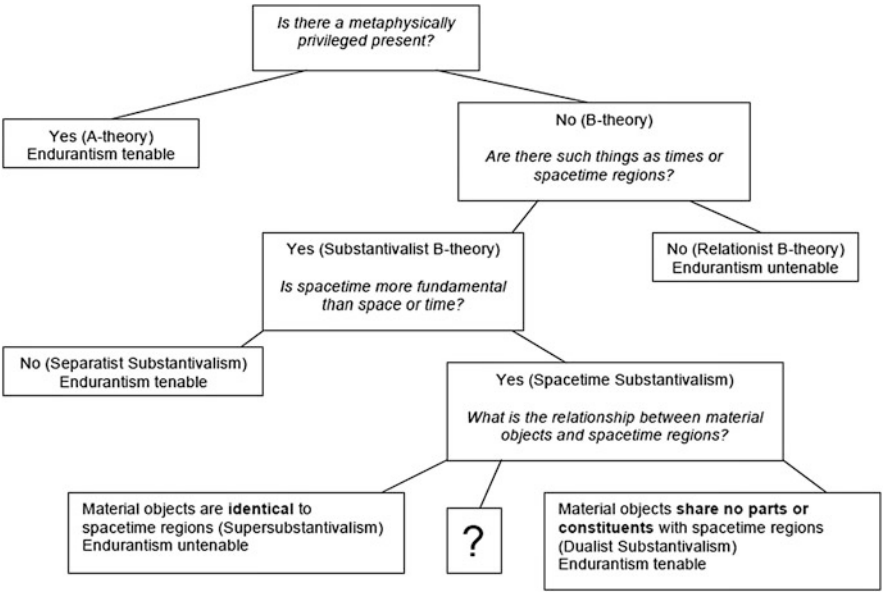


**Fig. 1.1** Time and persistence

substantivalism with endurantism, how should one do it? Let me be more specific. Suppose that, on the basis of considerations given in support of (1), one rejects *dualistic substantivalism*, the view that material objects *occupy* spacetime regions but are never identical with any region and indeed never even share any parts or constituents with any region. In that case, how should one combine spacetime substantivalism and endurantism?

In this chapter I explore several such combinations, some of them new, and I chart pros and cons of each. Though I take no stance on which, if any, of these packages is true, I suggest that some are promising and worthy of further attention. (See Fig. 1.1 for a map of the terrain covered so far. A 'close up' on spacetime substantivalism – and its species – appears toward the end of the chapter.)

## 1.2 From Substantivalism to Supersubstantivalism to Perdurantism

In this section I give a quick sketch of the considerations in support of (1) and (2).

(1) Given spacetime substantivalism, there seem to be two main options concerning the status of material objects. First, one can be a dualist substantivalist, in the sense described above. This has been the standard default position for virtually all spacetime-friendly endurantists and even for some perdurantists (Hudson 2001, 2005). Second, one can say that each material object is identical

to some spacetime region – specifically, the object's path, the region that exactly contains the object's complete career or life-history. This is *supersubstantivalism*.[6] (As I noted above, supersubtantivalism becomes a tenable option only given substantivalism about *spacetime*. Substantivalists who take space and time to be separate and fundamental entities have no locations with which material objects can be plausibly identified.) Of these two views – dualist substantivalism and supersubstantivalism – considerations of parsimony favor the latter. Dualist substantivalism is unparsimonious with respect to *ontology*, since it embraces (i) sui generis, substantival spacetime points and/or regions and (ii) sui generis material objects that occupy spacetime but that are not in any way constructed from the same basic ingredients as spacetime. And dualist substantivalism is unparsimonious with respect to *ideology*, since its proponents will presumably need some primitive, fundamental occupation predicate to state the facts about how material objects relate to spacetime regions. Supersubstantivalism economizes on ontology, since it avoids sui generis material objects, and it economizes on ideology, since it has no need for a primitive, fundamental occupation predicate. According to the supersubstantivalist, for a material object to *occupy* a region is just for the material object to *be* that region.

Jonathan Schaffer offers a number of further considerations that he takes to favor supersubstantivalism over dualist substantivalism. Two of his arguments are worth quoting at length:

> The argument from General Relativity: General Relativistic models are Triples $<M, g, T>$ where M is a four-dimensional continuously differentiable point manifold, g is a metric-field tensor, and T is a stress-energy tensor (with both g and T defined at every point of M, and with g and T coupled by Einstein's field equations). *There are no material occupants in* $<M, g, T>$ *triples*. That is, the distribution of matter in General Relativity is not given via a list of material objects in occupation relations to regions. Rather the distribution is given by the stress-energy tensor, which is a field, and thus naturally interpreted as a *property of the spacetime* ... Thus Earman suggests identifying M with the spacetime manifold, and treating g and T as properties of M: 'Indeed, modern field theory is not implausibly read as saying the physical world is fully described by giving the values of various fields, whether scalar, vector, or tensor, which fields are attributes of the space-time manifold M' (Earman 1989, p. 115; Schaffer 2009, 142, italics original).
>
> The argument from Quantum Field Theory: Quantum Field Theory, like General Relativity, is a theory of fields (which again are naturally interpreted as states of the spacetime) rather than material occupants. ... Thus in quantum field theory, 'particles' turn out to be excitation properties of spacetime itself, as d'Espagnat explains: 'Within [quantum field theory] particles are admittedly given the status of mere properties, ... but they are properties of something. This something is nothing other than space or space-time, which, being locally structured (variable curvature), have indeed enough 'flexibility' to possess

[6] As I will understand it, supersubstantivalism is neutral as to which regions count as material objects. (Every region? Every 'matter-filled' region? Every maximal continuous matter-filled region?) And then there is the further question of what counts as being 'matter-filled'. Presumably this will need to be spelled out in field-theoretic terms, but even so the answer is hardly straightforward. Again, supersubstantivalists are free to disagree amongst themselves on these questions. They are united only in claiming that all material objects are regions.

infinitely many 'properties' or particular local configurations' (Schaffer 2009, 142–3, italics original).

At the very least, Schaffer makes a convincing case to the effect that *many leading authorities* in physics and the philosophy of physics believe that sui generis material objects play no role in General Relativity or Quantum Field Theory and, further, that the existence of such material objects may be positively in tension with these theories. (See Schaffer's paper for many further quotations and references.) On the assumption that substantivalists must choose between dualistic substantivalism and supersubstantivalism, then, the case for (1) is strong.

(2) Why think that supersubstantivalists ought to be perdurantists, not endurantists? The answer, roughly, is that spacetime perdures. More carefully: if spacetime region r is the path of *persisting* object, then – barring some highly exotic view about spacetime[7] – r perdures; in particular, r is temporally extended and has (proper) temporal parts. So, if o is *identical* to r, then o perdures too. All persisting material objects perdure, according to supersubstantivalism.

In sum: for those metaphysicians who are seeking to develop a viable form of endurantism that harmonizes with physics, there is reason to hope that endurantism can be freed from a commitment to dualistic substantivalism. Not only does dualistic

[7]Here are four such views. (i) **Extended Simple Regions**. Spacetime might be composed of spatially and temporally extended but mereologically simple 'grains'. (See Braddon-Mitchell and Miller (2006) and Dainton (2010) for discussion of related views.) Such a grain might count as persisting (since it's temporally extended), but it wouldn't have any proper temporal parts, and so might not count as perduring. (ii) **Spatially Gunky Spacetime**. Spacetime might be 'spatially gunky' and altogether lacking in proper temporal parts: suppose that every spacetime region is complex, spatially extended, and of infinite temporal extent in both temporal directions, so that each region is eternal and composed of spatially smaller regions. These regions would count as persisting but not as perduring (and even opponents of extended simples can believe in them). (iii) **Restricted Composition on Spacetime Points**. Suppose that all spacetime regions are composed of spatially-and-temporally-unextended, mereologically simple spacetime points, and that some spacetime points compose something iff they are arranged 'complete path of a living organism'-wise. Then, since no living organism has a spacetime point or another living organism as a proper temporal part (let's assume), it's plausible that no temporally extended region has any proper temporal parts. (The pluralities of simples that would compose the temporal parts of such regions, if they composed anything, do not in fact compose anything.) In that case there could be regions that persist but do not perdure. (iv) **Mereologically Coinciding Regions Without Strong Supplementation**. Suppose that all spacetime regions are composed of spatially-and-temporally-unextended simple spacetime points and that every plurality of points composes a region. But suppose further that there is at least one plurality of points, the ps, that compose two different regions, r1 and r2, such that: (a) r1 and r2 are both spatially and temporally extended, (b) r1 has a full distribution of proper temporal parts, and (c) r2 does not have any proper temporal parts. Thus the relationship between r1 and r2 is like the relationship between a statue and a lump that are composed of the same simples but that differ in that the head of the statue is a part of the statue but not of the lump. (Strong Supplementation – the principle that if x is not a part of y, then x has some part that fails to overlap y – is violated in such cases.) In such a case r2 would persist but not perdure. (Eagle (2010) floats a view that sanctions mereologically coincident spacetime regions but does not suggest that they might different with respect to having temporal parts.)

substantivalism fail the parsimony test, but experts tell us that it's in tension with our best physical theories.

## 1.3 First Compromise: The Path Constitution View

Fortunately, there is room to maneuver here. For even if we accept spacetime substantivalism and reject full-blown dualism about regions and their material occupants, we need not embrace supersubstantivalism.

### *1.3.1 Outlining the View*

Instead of taking material objects to be *identical* with the regions that are their paths, one might take them merely to *coincide mereologically* with those regions. The idea would be that the relationship between a material object and its spacetime path is the same as the relationship often taken to hold between a statue and the lump of clay that constitutes it: mereological coincidence without identity. (Say that x *mereologically coincides with* y if and only if x and y overlap – share parts with – exactly the same things.) As far as I am aware, this view was first entertained in print by John Hawthorne:

> One might take the further step of not treating occupation as fundamental. The statue and lump are mereologically coincident. Perhaps they are also mereologically coincident with a spatiotemporal region. Occupation can then be defined in terms of mereological relations to regions. And just as we typically picture the statue as inheriting certain properties – weight and so on – from the lump by mereological coincidence, we can here think of various objects as inheriting various magnitudes associated with fields by mereological coincidence with spacetime regions which in turn are the fundamental bearers of field values (Hawthorne 2006, 118, n. 18).

Following Schaffer, let's use the term 'monistic substantivalism' for the view that each material object is either identical to or mereologically coincident with some spacetime region. Monistic substantivalism comes in two main versions: the *identity* version, a.k.a. *super*substantivalism, which holds that each material object just is a region, and the *constitution* version, which holds that at least some material objects are not identical to any region, but that each of them coincides mereologically with a region.

The constitution view achieves some measure of ontological parsimony, since it treats material objects not as *sui generis* entities but as things that, informally speaking, are composed of the same basic ingredients as spacetime regions themselves, and it is parsimonious with respect to ideology, since it allows us to define 'occupies' as 'coincides with', rather than treating it as a fundamental primitive. Further, as Schaffer notes, it harmonizes with General Relativity and Quantum Field Theory:

> The constitution ... [version] of monism can claim parsimony, and can claim fit with General Relativity and Quantum Field Theory, insofar as these issues only concern the fundamental ontology. The constitution views preserve the fundamental ontology of a spacetime bearing fields (Schaffer 2009, 143–144).

Suppose, then, that we opt for the constitution view.

How would this help endurantism?[8] It's not at all clear that it would, since it's tempting to think that if x mereologically coincides with y, and y perdures, then x perdures too. But one possibility is this. In opting for the constitution view, we open up logical space for the doctrine that a given plurality of spacetime points, the ps, compose (at least) two things: (i) a region, r, which is temporally extended and has a full distribution of instantaneous and non-instantaneous temporal parts, *the ts*, and (ii) a material object, o, which is temporally extended and co-located with r, but which does not have any of the ts as parts and indeed does not have any proper temporal parts at all. (Presumably o and r differ with regard to their de re modal profile as well, so that o but not r could have had, say, a shorter temporal duration.) The core idea here is that the relationship between o and r is like the relationship between a statue and a lump of clay that are both composed of the same simples but that do not have exactly the same parts: e.g., the statue, but not the lump, has the *head* of the statue as a part (Lowe 2003). (As pointed out in note 7, this requires rejecting Strong Supplementation, the principle that says that if x is not a part of y, then x has a part that fails to overlap y.) At this point it will be convenient to fill in some details that have so far been implicit:

*The Path Constitution View*

*Absolutism:* There is only one fundamental parthood relation, it is a two-place relation (expressed by 'x is a part of y'), and it does not hold relative to times, locations, sortals, or anything else.

*Plenitude for Regions:* Each set of spacetime (points and/or[9] ) regions has at least one spacetime region as a fusion.[10]

*Path Coincidentalism:* Each material object coincides with a spacetime region (its path), but no material object is identical to any spacetime region.

*No Fundamental Occupation:* The predicate 'x occupies y' is not fundamental; it is defined in mereological terms, as 'x coincides with y', or perhaps 'y is a region, and x coincides with y'.

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[8] Hawthorne (2006) and Schaffer both seem to think that the constitution version is friendlier to certain forms of endurantism than is the identity version, although neither goes into much detail on this point. Hawthorne focuses mostly on forms of endurantism (framed in terms of grounding or metaphysical dependence) that will not concern us here. Schaffer's reason for taking the constitution-version to be endurance-friendly is not clear to me. He writes that 'the constitution view ... does not entail four-dimensionalism .... Presumably the constituted object could have different persistence conditions than its constituting matter [a spacetime region]' (Schaffer 2009, 137).

[9] Henceforth points (if there are any) count as regions.

[10] This view would fail if (i) some sets of regions had no fusion at all, in which case a form of restricted composition would be true or (ii) some set of regions had more than one spacetime region as a fusion, as discussed in note 7.

*Regions Have Temporal Parts:* Each persisting spacetime region has proper temporal parts.

*Objects Lack Temporal Parts:* There are material objects, but none of them has proper temporal parts.

*Parts of Objects:* A material object x is a part of a material object y only if some region that x occupies is a part of some region that y occupies.

The Path Constitution View (PCV) takes no stand on which spacetime regions constitute material objects. (Every region? Every region at which certain fields have an everywhere positive value?) Nor does it take a stand on *how many* material objects are constituted by a given region that constitutes at least one material object. (One? Two? Continuum-many?)

We've already mentioned the main virtues of the PCV: parsimony, fit with GTR and QFT, and – for those with endurantist sympathies – avoidance of temporal parts of material objects.

One potential drawback of PCV – for those who are attracted to a certain brand of endurantism – is that it treats persisting material objects as temporally extended and singly located in spacetime. Second, and relatedly, PCV denies that any fundamental parthood relation ever holds between, say, an oxygen atom with a one billion year-long career and a human being with a 90-year-long career. For it often happens that the path of such an atom *overlaps* the path of a human being, but it never happens that the path of such an atom is a *part* of the path of a human being. I elaborate on these issues below. Toward the end of the paper I will mention a pair of problems that afflict all three of the compromise positions to be discussed in this paper.

### *1.3.2 Problems for the Path Constitution View*

In stating these problems it will be convenient to work with precise definitions of three notions: the notion of being *weakly located* at a region, the notion of an object's *path*, and the notion of *persisting*. Our definitions will invoke (i) a primitive predicate for parthood (which we take to be reflexive and transitive) and (ii) a predicate for occupation. Informally, to say that x occupies r is to say that x has (or has-at-r) exactly the same shape and size as r and stands (or stands-at-r) in all the same spatiotemporal relations to things as does r. But of course the friend of PCV does not take 'occupies' as primitive; rather she defines it in terms of mereological coincidence as specified earlier.

Now for the definition of 'is weakly located at'. Intuitively, to say that x is weakly located at r is to say that r is 'not completely free of' x (Parsons 2007); thus Russia is weakly located in Europe, in Asia, in Siberia, and in the Milky Way, but not in the Andromeda Galaxy. (Pretend that Russia is a material object and the rest are all spacetime regions). Our official definition will be this: 'x is weakly located at r' means '$\exists r^*$[x occupies $r^*$ & $r^*$ overlaps r]'. In words: 'x occupies something that overlaps r', where 'overlaps' means 'shares a part with'.

As for the notion of an object's path: intuitively, my path is the spacetime region that I exactly sweep out over the course of my career. Although it is natural to speak as though each object has at most one path, we will not build this into our definition. We will say: 'r is a path of x' means '$\forall r^*$ [r overlaps $r^* \leftrightarrow x$ is weakly located at $r^*$]', that is, 'r overlaps all and only those entities at which x is weakly located'. It follows from this definition (together with the reflexivity of parthood) that if both r and r* are paths of x, then r and r* coincide. So, although we won't assume that no object has more than one path, we are committed to the view that no object has two paths that fail to coincide with each other.

Finally, we can say that 'x *persists*' means '$\exists r \exists r_1 \exists r_2$ [r is a path of x & $r_1$ is a part of $r$ & $r_2$ is a part of $r$ & $r_1$ absolutely earlier than $r_2$]'. In other words, to persist is to have a path some parts of which are absolutely earlier than others. So much for definitions.

Now, just as a matter of usage, when one says that a thing 'endures', one can mean at least two things. First, one can mean that the thing persists but does not have temporal parts. Call this *mereological endurance*. Second, one can mean that the thing persists and occupies many different spacetime regions, each of them instantaneous or spacelike. Call this *locational endurance*. There is a corresponding ambiguity in the term 'perdure'. When one says that a thing perdures, one can mean that it persists and has (a sufficiently full distribution of) temporal parts, or that it persists and occupies only its path (or paths, if it has more than one). Call the former *mereological perdurance* and the latter *locational perdurance*. (See Gilmore 2006 for more on this.)

Some philosophers seem to think that material objects endure both mereologically and locationally, while others seem to think that they perdure both mereologically and locationally. But there is logical space for mixed views. One might take material objects to mereologically endure but locationally perdure, or to mereologically perdure but locationally endure. See Fig. 1.2 (from Gilmore 2008, 1230) for an illustration of these options.

As we have seen, PCV accommodates mereological endurance. Since there is logical space to say that two entities coincide with having exactly the same parts, there is logical space to say that Obama lacks temporal parts but coincides with a spacetime region that has temporal parts.

**Problem 1: PCV rules out locational endurantism.** However, PCV does not accommodate locational endurance. Given the definition of 'occupies' in No Fundamental Occupation, we get the result that any two regions occupied by Obama coincide with each other. But, together with our other definitions, this entails that Obama occupies only his path(s), that is, that he locationally *perdures*.

Loosely stated, the problem is this. The locational endurantist wants to say that (i) although Obama's path is temporally extended, each of the regions that Obama occupies (each of his 'locations') is temporally unextended, and that (ii) there are a great many pairs of these locations that do not even overlap, much less coincide. But given the definition of 'occupies' built into PCV, we cannot say that. Instead, we have to say that Obama occupies only those regions with which he coincides. And he can coincide with two different regions only if they coincide with each other. So he

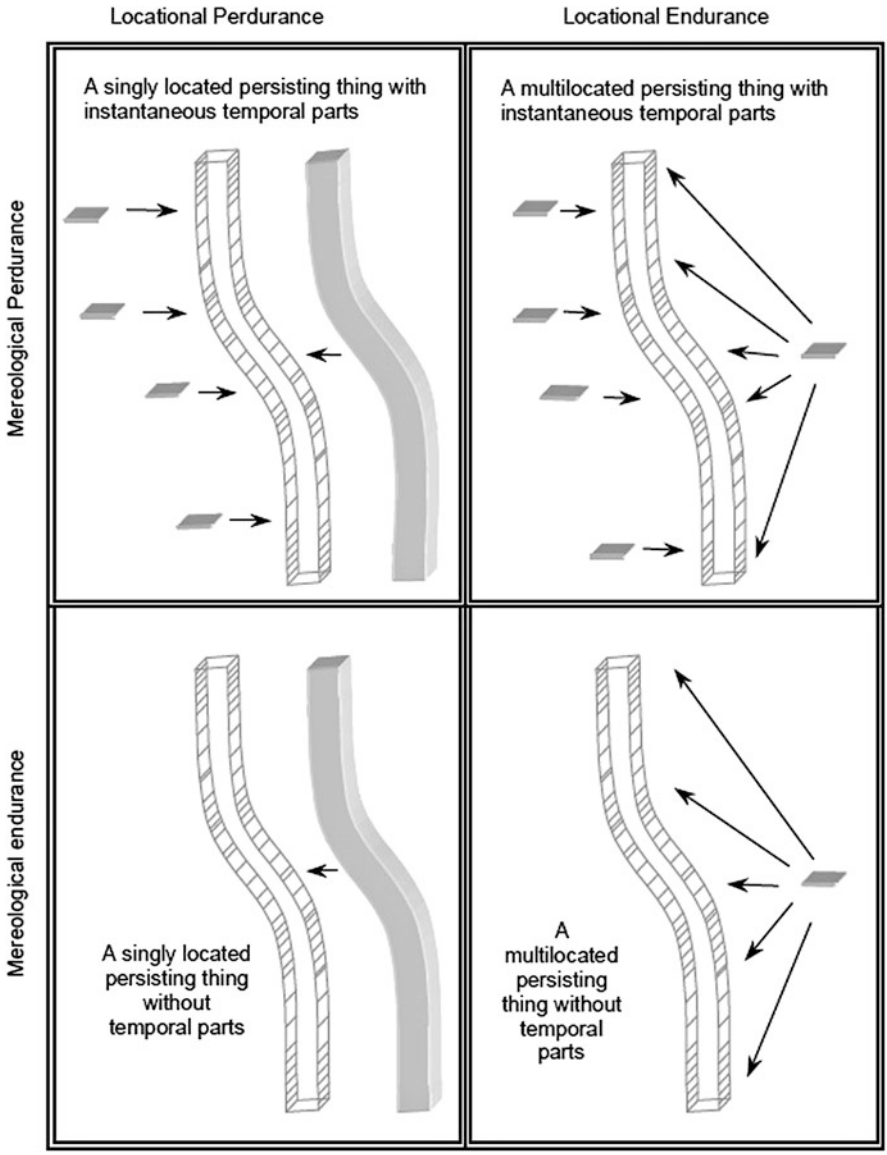



**Fig. 1.2** Four forms of persistence

can *occupy* two different regions only if they coincide with each other. He cannot occupy two *non-coinciding* regions, not to mention two *non-overlapping* regions. So, for what it's worth, locational endurantists will need to reject PCV. This is the first potential drawback mentioned above.

**Problem 2: Gain and loss of parts (in a fundamental sense of 'part').** Now let me turn to the second potential drawback for PCV. Consider some material object m that satisfies the following conditions: (i) we would ordinarily describe m as being a *part* of Obama *at some time*, (ii) m's path overlaps Obama's path, and (iii) m's path is not part of Obama's path, perhaps because m pre-dates or post-dates Obama, or perhaps because m is for some period of time spatially outside of Obama. In particular, (iv) some parts of m's path fail to overlap Obama's path, and some parts of Obama's path fail to overlap m's path. The object m might be an electron, an oxygen atom, or a tooth that was pulled when Obama was a boy. For concreteness, let's supposes it's a DNA molecule. Given these assumptions, PCV tells us that no fundamental parthood relation holds between m and Obama. Granted, if m had temporal parts, then some *temporal part* of m might be a part, in the fundamental sense, of Obama; and m itself might be a part of Obama in some *non-fundamental sense*; but m itself is not in any fundamental sense a part of Obama.[11]

Intuitively, however, m itself is a part of Obama, in some fundamental sense of 'part'. Put more carefully: there is some fundamental parthood relation R such that, if R is two-place, then R is instantiated by m and Obama in that order (or by the ordered pair <m, Obama>), and if R is a three-or-more-place relation, then it's instantiated by m, Obama, and some further relata (or by some ordered -tuple containing m and Obama).

In short, people have DNA molecules as parts, in some fundamental sense of 'part'. We should accommodate this point if we can do so without paying too high a price. PCV doesn't accommodate it. So we should look elsewhere.

## 1.4 Second Compromise: The Many-Slice Constitution View

Why does PCV rule out locational endurantism? In nutshell, it's because PCV says that (i) *occupying* a region requires *coinciding* with that region and that (ii) a thing can't coincide with each of many non-overlapping regions. The commitment to (ii) arises from the fact that PCV assumes that parthood is reflexive and transitive and that 'x coincides with y' is defined as '∀z [z overlaps x iff z overlaps y]'. These are highly plausible assumptions in the context of the claim, made explicit in Absolutism, that the relevant fundamental parthood relation is two-place.

But Absolutism is negotiable. Indeed, almost everyone who accepts both endurantism and B-theoretic eternalism *already* rejects Absolutism for independent

[11]To see this, note first that, given PCV together with our set-up, no region occupied by m is a part of any region occupied by Obama. But then, by Parts of Objects, we get the result that m is not a part of Obama. So the fundamental parthood relation expressed by 'is a part of' doesn't hold between m and Obama. And according to Absolutism, this is the *only* fundamental parthood relation.

reasons.[12] The idea goes roughly as follows. Objects gain and lose parts over time. A certain DNA molecule, m, is a part of Obama at one time but not at another. If the present were metaphysically privileged, we might be able to capture this fact in terms of tense operators and a two-place parthood predicate: $\neg Part(m, obama) \& WAS[Part(m, obama)]$. If things had temporal parts, we could try to capture the fact in terms of a non-fundamental, time-relative parthood predicate, defined in terms of the notion of a temporal part and ultimately in terms of a fundamental two-place parthood predicate (Sider 2001). But without temporal parts or a privileged present, the most natural option is to say that the fundamental parthood relation holding between material objects is a more-than-two-place relation.

It bears repeating that this is an *independent* motivation for dropping Absolutism. Making room for monistic substantivalism has typically been the farthest thing from endurantists' minds. And yet they – or at least the B-theoretic eternalists among them – have already rejected Absolutism almost universally.

But it turns out that once we drop Absolutism, we can articulate a natural notion of coincidence (or 'coincidence-at') in terms of which we can say that a given object coincides (at different times or locations) with different regions that do not overlap (at any time or location) each other. This lets us say that Obama occupies – and coincides with – each in a series of temporally unextended spacetime regions, just as a wave coincides (at different times) with each in a series of wave-shaped portions of water. Thus by dropping Absolutism, we open up a way to combine locational endurantism with monistic substantivalism.

As before, we will need to reject (the appropriately restated version of) Strong Supplementation if we are to avoid the result that persisting material objects have temporal parts. For we will assume that each material object *mereologically coincides* with each in a series of instantaneous slices of the object's path. If it turned out that the material object had these slices as *parts*, they would count as *temporal* parts of the object. So we will need to say that, in some cases, an object x mereologically coincides with an object y but does not have y as a part. This conflicts with Strong Supplementation.

### *1.4.1 Outlining the View*

I suspect that this basic strategy can be implemented in a variety of ways, depending upon what Absolutism is replaced with. One tempting suggestion is to replace it with

[12]Many have argued that the fundamental parthood relation for material objects is a three-place relation expressed by 'x is a part of y at z', with two slots for material objects and one slot for a time (Koslicki 2008; Thomson 1983; Van Inwagen 1990) or a region of space or spacetime (Donnelly 2010; Hudson 2001; McDaniel 2004; Rea 1998). As far as I am aware, the only self-described B-theoretic endurantist who accepts Absolutism is Parsons (2000, 2007).

*(3P)* The fundamental parthood relation for material objects is a three-place relation expressed by 'x is a part of y at z', with one slot for the part, one slot for the whole, and a third slot for a time, region of space, or region of spacetime.

On the basis of considerations that do not concern monistic substantivalism, I have argued (Gilmore 2009) that 3P is inferior to

*(4P)* The fundamental parthood relation for material objects is a four-place relation expressed by 'x at y is a part of z at w', with one slot for the part, one slot for a *location* of the part (e.g., a spacetime region), one slot for the whole, and one slot for a *location* of the whole (e.g., a spacetime region).[13]

So I will make use of 4P in what follows. For all I know, 3P and 4P would both serve equally well for task at hand in this chapter. I am opting for 4P only because I take it to be preferable on grounds that will not concern us here.

Now, to help firm up the reader's grasp of my proposed four-place parthood relation, let me set out some principles that plausibly govern it. I'll get all these principles (and some associated definitions) out on the table quickly, then I'll supply some examples, in diagram form, that should help to clarify the principles. So please bear with me. First, the *Location Location Principle*:

$(LLP)\ \forall x \forall y \forall z \forall w [P(x, y, z, w) \rightarrow [L(x, y) \& L(z, w)]]$
If x at y is a part of z at w, then x occupies y and z occupies w.

This just makes explicit the assumption that the second and fourth slots are reserved for locations of the part and whole, respectively. Second, an analogue of the reflexivity of parthood:

$(R_{4P})\ \forall x \forall y [L(x, y) \rightarrow P(x, y, x, y)]$
If x occupies y, then x at y is a part of x at y.

We can't say 'for all x and all y, x at y is a part of x at y' since, together with *LLP*, this would entail that everything occupies everything, which is obviously false. $R_{4P}$ is the most natural alternative. Third, an analogue of the transitivity of parthood:

$(T_{4P})\ \forall x_1 \forall y_1 \forall x_2 \forall y_2 \forall x_3 \forall y_3\ [[P(x_1, y_1, x_2, y_2) \& P(x_2, y_2, x_3, y_3)] \rightarrow P(x_1, y_1, x_3, y_3)]$

It will also be useful to define predicates for overlapping and coincidence:

$(D_O)\ O(x_1, y_1, x_2, y_2) = df\ \exists x_3 \exists y_3\ [P(x_3, y_3, x_1, y_1) \& P(x_3, y_3, x_2, y_2)]$
'$x_1$ at $y_1$ overlaps $x_2$ at $y_2$' means 'some $x_3$ at some $y_3$, is a part both of $x_1$ at $y_1$ and of $x_2$ at $y_2$'

$(D_C)\ CO(x_1, y_1, x_2, y_2) = df\ [L(x_1, y_1) \vee L(x_2, y_2)] \& \forall x_3 \forall y_3\ [O(x_3, y_3, x_1, y_1) \leftrightarrow O(x_3, y_3, x_2, y_2)]$

[13] Kleinschmidt (2011) independently proposes 4P and some of the same 4P-appropriate mereological principles to be given here. But she eventually rejects 4P.

'$x_1$ at $y_1$ coincides with $x_2$ at $y_2$' means 'either $x_1$ occupies $y_1$ or $x_2$ occupies $y_2$, and for any $x_3$ and $y_3$, $x_3$ at $y_3$ overlaps $x_1$ at $y_1$ if and only if $x_3$ at $y_3$ overlaps $x_2$ at $y_2$'

The first clause in $D_C$ is needed to avoid the result that Obama, at a region $r_1$ on the moon, coincides with Putin, at a region $r_2$ on Jupiter. (Since Obama does not occupy $r_1$, nothing (at any location) is a part of him there, and so nothing (at any location) overlaps him there. Similarly for Putin and $r_2$. It follows that exactly the same things, at exactly the same locations, overlap Obama at $r_1$ as overlap Putin at $r_2$.) With the first clause in place, however, we can show (given $R_{4P}$, $T_{4P}$, and $D_O$) that if $o_1$ at $r_1$ coincides with $o_2$ at $r_2$, then $o_1$ occupies $r_1$ *and* $o_2$ occupies $r_2$. In slogan form: you can't coincide with things at regions at which you don't occupy. We will also want to define a predicate for fusion. To do this, we can think of fusion as a three-place relation that holds between a *thing*, a *set*, and a *location* of the thing, where the set in question is a set of ordered <thing, location of that thing> pairs:

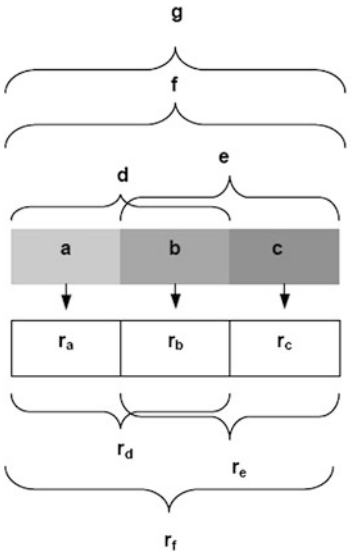
$$(D_F)\ F(y, s, y^*) =_{df} \exists z(z \in s) \& \forall z\,[z \in s \rightarrow \exists w \exists w^* [z = <w, w^*> \& P(w, w^*, y, y^*)]] \& \forall z \forall z^*\,[P(z, z^*, y, y^*) \rightarrow \exists u \exists w \exists w^*\,[u \in s \& u = <w, w^*> \& O(w, w^*, z, z^*)]]$$

In words, y fuses s at y* just in case: (i) s is a non-empty set, (ii) each member of s is an ordered pair whose first member at its second member is a part of y at y*, and (iii) for any z and any z*, if z at z* is a part of y at y*, then there is some ordered pair in s whose first member at its second member overlaps z at z*. $D_F$ does not have the result that material objects have sets or ordered pairs as parts. When a thing fuses a set of ordered pairs, it has the *first members* of those ordered pairs as parts, not the pairs themselves, and not the set of them.

Now for a pair of diagrams to illustrate these concepts. Figure 1.3 depicts a case in which two different composite objects (f and g) fuse the same simples (a, b, and c) and hence count as coinciding. These composite objects also occupy the same region. Figure 1.3 may also be useful in that it illustrates cases of overlapping and cases in which our reflexivity and transitivity principles ($R_{4P}$ and $T_{4P}$) apply. The *raison d' étre* of three-place or four-place parthood is the need to accommodate cases in which an object is *multilocated* (occupies two or more non-coinciding spacetime regions) and exhibits *mereological variation* from one location to another (has parts at one of its locations that it does not have at another). Multilocation is missing from Fig. 1.3. So it will be useful to consider another case.

In the case depicted by Fig. 1.4, m is a composite object that occupies two different regions: $rm_1$ and $rm_2$. Further, m has different parts at different locations: at $rm_1$, $m$ has $d$ but not $a$ as a part, and at $rm_2$, $m$ has $a$ but not $d$ as a part.

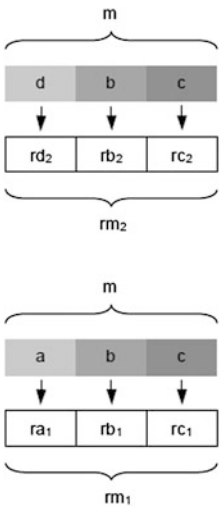
We can think of $m$ as being analogous to an enduring human being who is composed of different parts at different times at which it exists or at different spacetime regions that it occupies. At the earlier region $rm_1$, $m$ is composed of $a$, $b$, and $c$ (at certain locations of these objects) and at the later region $rm_2$, $m$ is composed of $d$, $b$, and $c$ (at certain later locations of these objects).




**Some facts about the case**

1. a – g are material objects
2. $r_a$ – $r_f$ are spacetime regions
3. $g \neq f$
4. a occupies $r_a$, . . . , f occupies $r_f$, and g occupies $r_f$
5. a at $r_a$ is a part of a at $r_a$ (by 4 and $R_{4P}$)
6. b at $r_b$ is a part of d at $r_d$
7. b at $r_b$ is a part of e at $r_e$
8. d at $r_d$ overlaps e at $r_e$ (by 6, 7, and $D_O$)
9. e at $r_e$ is a part of f at $r_f$
10. b at $r_b$ is a part of f at $r_f$ (by 7, 9, and $T_{4P}$)
11. f fuses the set {<a, $r_a$>, <b, $r_b$>, <c, $r_c$>} at $r_f$, as does g
12. f fuses the set {<d, $r_d$>, <e, $r_e$>} at $r_f$ , as does g
13. f at $r_f$ coincides with g at $r_f$

**Fig. 1.3** Four-place parthood




**Some facts about the case**

1. a – m are material objects
2. $ra_1$ – $rm_2$ are instantaneous spacetime regions
3. $rm_1$ and each of its parts is absolutely earlier than $rm_2$ and each of its parts; $rm_1$ and $rm_2$ do not overlap
4. m occupies exactly two regions, $rm_1$ and $rm_2$; m does *not* occupy any proper sub- or superregions of these
5. b and c each occupies exactly two regions: b occupies $rb_1$ and $rb_2$, c occupies $rc_1$ and $rc_2$
6. a at $ra_1$ is a part of m at $rm_1$
7. it is not the case that: a at $ra_1$ is a part of m at $rm_2$
8. $\sim\exists r$[a at r is a part of m at $rm_2$], in words: a is not, anywhere, a part of m at $rm_2$.
9. d at $rd_2$ is a part of m at $rm_2$.
10. $\sim\exists r$[d at r is a part of m at $rm_1$], in words: d is not, anywhere, a part of m at $rm_1$
11. m fuses {<a, $ra_1$>, <b, $rb_1$>, <c, $rc_1$>} at $rm_1$
12. m does *not* fuse {<d, $rd_2$>, <b, $rb_2$>, <c, $rc_2$>} at $rm_1$
13. m fuses {<d, $rd_2$>, <b, $rb_2$>, <c, $rc_2$>} at $rm_2$
14. m does *not* fuse {<a, $ra_1$>, <b, $rb_1$>, <c, $rc_1$>} at $rm_2$

**Fig. 1.4** Four-place parthood and multilocation

So far I have been suppressing a pair of important questions. First, is 'occupies' ('L') defined, and if so how? Second, how does the sub-region relation that holds between regions relate to the parthood relation that holds between material objects? I answer the first question affirmatively and give the following definition:

$(D_L)$ $L(x, y) =_{df} \exists z \exists w\, [P(x, y, z, w) \vee P(z, w, x, y)]$
'x occupies y' means 'either x at y is part of some z at some w, or some z at some w has x at y as a part'

As a slogan: to occupy a location is to *be* a part of something there or to *have*, there, something as a part. As for the second question, since we are emphasizing ideological parsimony in this chapter, we will operate under the assumption that there is just one fundamental parthood relation, and that it holds both between material objects and between regions (among other things, perhaps). Thus, if region $r_1$ is, intuitively, a *subregion* or *part-simpliciter* of $r_2$, then we should say that $r_1$ at $r_1$ is a part of $r_2$ at $r_2$. If we like, we can go further and define a two-place predicate for parthood *simpliciter* (which then comes out as a non-fundamental relation):

$(D_{PS})$ $P^2(x_1, x_2) =_{df} \exists y_1 \exists y_2\, [P(x_1, y_1, x_2, y_2) \& \forall y_3 \forall y_4$
$[[L(x_1, y_3) \& L(x_2, y_4)] \rightarrow P(x_1, y_3, x_2, y_4)]]$

In words, '$x_1$ is a part-simpliciter of $x_2$' means '$x_1$, somewhere, is a part of $x_2$, somewhere, and for any locations $y_3$ and $y_4$ of $x_1$ and $x_2$, respectively, $x_1$ at $y_3$ is a part of $x_2$ at $y_4$'. Presumably regions are singly located (occupying themselves only); at the very least it seems certain that no region occupies two non-coinciding regions. This makes it plausible that if region $r_1$ is, at $r_1$, a part of region $r_2$ at $r_2$, then $r_1$ is a part-simpliciter of $r_2$.

With the understanding that *regions*, no less than *material objects*, can fill the 'part' slot and 'whole' slot in our four-place parthood relation, we are now in a position to set out a principle that links (i) facts about the mereological relationship between a pair of objects with (ii) facts about the mereological relationship between the *locations* of those objects. I will call it *Withinness*:

$(W_{4P})$ $\forall x_1 \forall y_1 \forall x_2 \forall y_2\, [(x_1, y_1, x_2, y_2) \rightarrow P(y_1, y_1, y_2, y_2)]$
If $x_1$ at $y_1$ is a part of $x_2$ at $y_2$, then $y_1$ at $y_1$ is a part of $y_2$ at $y_2$.

Intuitively, this says that if Obama's right arm, at region $r_{ra}$, is a part of Obama, at region $r_o$, then the 'arm-region' is a part of the 'Obamba-region' – in four-place terms, $r_{ra}$ at $r_{ra}$ is a part of $r_o$ at $r_o$. There are a number of further principles that we could set out that plausibly link 'mereological' facts to 'locational' facts, but $W_{4P}$ is enough for now. (Strictly speaking, these facts are all mereological, since we're working with just one non-logical primitive: our four-place parthood predicate.)

So far, everything that I have said concerning our four-place parthood relation should seem at least as plausible to the *dualist* substantivalist as to the *monist* substantivalist. Indeed, most of what I have said about that relation here just summarizes what I have said elsewhere (Gilmore 2009; forthcoming a), working under dualist presuppositions.

But now that we have this framework in place, we can simply *drop the tacit dualism*, and everything else should remain intact. In particular, we can say that each material object *mereologically coincides* with each spacetime region that it occupies:

($Monism_{4P}$) For any material object o and spacetime region r, if o occupies r, then: o at r coincides with r at r.

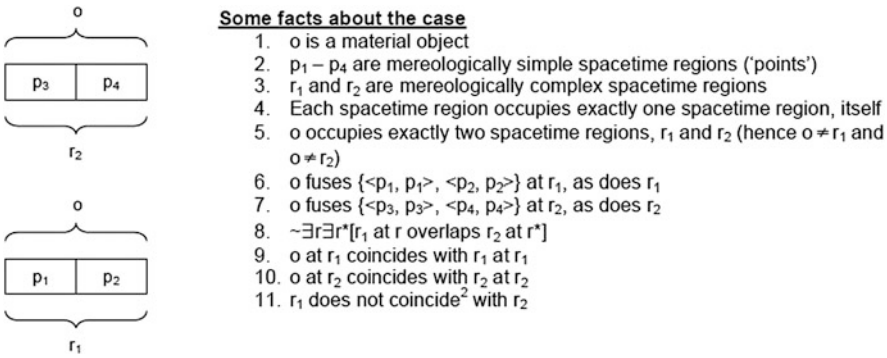



**Fig. 1.5** Monism$_{4P}$ and Locational Endurantism

According to this view, if Obama occupies the three-dimensional, instantaneous spacetime region $r_1$, then he, at $r_1$, mereologically coincides with $r_1$, at $r_1$; and in that case the relationship between him and $r_1$ is like the relationship between the material objects f and g in Fig. 1.1: coincidence without identity. Moreover, he can bear this relation of coincidence to many different regions that do not bear it to each other. Perhaps he also occupies the distinct region $r_2$. Then, given *Monism*$_{4P}$, it follows that Obama, at $r_2$, coincides with $r_2$, at $r_2$. But it does not follow that $r_1$ and $r_2$ even *overlap*, much less that they *coincide*: we remain free to say that $\neg\exists r\exists r*$ ($r_1$ at $r$ overlaps $r_2$ at $r*$ ) and hence that $\neg\exists r\exists r*$ ($r_1$ at $r$ coincides with $r_2$ at $r*$). If we define a two-place coincidence predicate as follows,

$(D_{C2})\ CO^2(x_1, x_2) =_{df} \exists y_1\exists y_2 CO(x_1, y_1, x_2, y_2)$
'$x_2$ coincides$^2$ with $x_2$' means '$x_1$, at some $y_1$, coincides with $x_2$, at some $y_2$'

then we can say, speaking quite strictly, that Obama coincides$^2$ with regions that do not coincide$^2$ with each other (since the two-place relation so defined is symmetric but not transitive). And of course, what goes for Obama also goes for any material objects that he ever has as parts, such as arms, legs, cells, or DNA molecules.

The analogy with waves is worth repeating. Just as a wave mereologically coincides, at different times, with different portions of water (where many pairs of these portions do not even overlap with each other), an enduring material object coincides$^2$ with many different instantaneous regions (many pairs of which do not overlap each other).

It may help to consider Fig. 1.5, which illustrates this combination of Monism$_{4P}$ and locational endurantism.

We should think of this as a simplified, highly unrealistic situation in which an object, o, has a complete spacetime path that is composed of just two instantaneous regions, the earlier region $r_1$ and the later region $r_2$.

The most important thing to note about the case is that it satisfies, in a precise way, both locational endurantism and monist substantivalism. The one material object in the case, o, occupies just the instantaneous, non-overlapping regions $r_1$ and

$r_2$; o does not occupy its temporally extended path, which, for simplicity, we have left out of the diagram altogether. Hence o locationally endures. Further, monist substantivalism is respected since, informally put, everything in the diagram is ultimately composed of spacetime regions. The regions themselves are of course composed of regions. But so is the one material object in the situation, o. It is composed of different spacetime points at different locations. At its location $r_1$, it is composed of the points $p_1$ and $p_2$. At its later location $r_2$, it is composed of $p_3$ and $p_4$.

Here is a general statement of the Many-Slice Constitution View (MSCV) that makes explicit some further details.

*The Many-Slice Constitution View*

*One Parthood*: There is only one fundamental parthood relation, and it holds both among material objects and among spacetime regions.

*4P*: The fundamental parthood relation for material objects is a four-place relation expressed by 'x at y is a part of z at w'.

*Plenitude for Regions*$_{4P}$: Each set of spacetime (points and/or) regions has at least one spacetime region as a fusion. In 4P-appropriate terms: for any non-empty set s, if each member of s is a spacetime (point or) region, then $\exists r\,[F(r, \{x : \exists y\,[y \in s\ \&\ x = <y, y>]\}, r)\ \&\ r$ is a spacetime region.

*Locational Endurantism*: Some material objects persist (have temporally extended paths), but no material object occupies any non-instantaneous (or non-spacelike) region.

*Constitution+Monism*$_{4P}$: For any material object o and spacetime region r: (i) $o \neq r$ and (ii) if o occupies r, then: o at r coincides with r at r.

*No Fundamental Occupation*$_{4P}$: There is no fundamental occupation relation; the predicate 'occupies' is defined in terms of a four-place parthood predicate, as specified in $D_L$.

*Regions Have Temporal Parts*: Each persisting spacetime region has proper temporal parts.

*Objects Lack Temporal Parts*: There are material objects, but none of them has proper temporal parts.

$W_{4P}$: If x at y is a part of z at w, then y at y is a part of w at w

Like PCV, MSCV leaves a number of questions open. It leaves open the question of which spacetime regions are 'material-object-paths', and which instantaneous slices of those paths are occupied by material objects. Further, it leaves open the question of whether a given instantaneous slice ever coincides with more than one material object.

### *1.4.2 How MSCV Avoids the Problems Facing PCV*

How does the Many-Slice Constitution View help with the two problems that we raised for the Path Constitution View?

**Problem 1: Ruling out locational endurantism.** The first problem (from an endurantist vantage point) was that PCV was committed to locational perdurantism and ruled out locational endurantism. Obviously MSCV solves that problem. It says that material objects occupy only instantaneous (or spacelike) regions.

**Problem 2: Gain and loss of parts.** The second problem was that PCV led to the result that a certain DNA molecule, m, is not a part of Obama, in any fundamental sense of 'part'. The underlying reason for this was that, in the case we considered, m's path extended outside of Obama's path, and according to PCV, the only regions that m and Obama occupy are their paths. Given the 'Withinness' principle, this forces us to say that m is not a part of Obama, in any fundamental sense of 'part'.

MSCV avoids this problem by maintaining that m has many locations, each of them an instantaneous slice of its path. Similarly for Obama. Given this, it will be natural for the friend of MSCV to say that many of m's locations are parts of some location or other of Obama, and that m is a part of Obama, in some fundamental sense of 'part'. To be more precise, the friend of MSCV will find it natural to say that there are spacetime region $r_m$ and $r_o$ such that: (i) m occupies $r_m$, (ii) Obama occupies $r_o$, (iii) $r_m$ at $r_m$ is a part of $r_o$ at $r_o$ (presumably $r_m$ is a part-simpliciter of $r_o$, in the sense defined earlier), and (iv) m at $r_m$ is a part of Obama at $r_o$.

Given $4P$, clause (iv) amounts to the claim that there is a fundamental parthood relation that holds between m and Obama (and two regions). Crucially, all this is perfectly consistent with the fact that m's path extends outside of Obama's path.

### *1.4.3 A Problem for the Many-Slice Constitution View and the Path Constitution View*

There is one core feature of both PCV and MSCV that many endurantists will see as a drawback[14]: the commitment to mereological-coincidence-without-identity.

Some philosophers apparently reject coinciding entities on something like 'purely mereological' grounds. They see the ban on these entities as (a) intuitively compelling on its own, or as (b) being justified by an analogy between composition and identity, or as (c) following from intuitively compelling principles concerning the behavior of parthood (reflexivity, strong supplementation, and anti-symmetry).

Others reject coinciding entities on the basis of the *grounding problem* (Bennett 2004). If coinciding objects x and y are not identical, presumably they differ with respect to certain properties – modal or historical ones, for example. But what could ground these differences, given that x and y coincide and hence are so similar physically? As applied to the thesis of object-region coincidence, the grounding

[14]B-theoretic endurantists who are on record in opposition to mereological coincidence without identity include Van Inwagen (1990), Burke (1994), Olson (1997), Rea (1998, 2000), Hershenov (2005), McGrath (2007), and Koslicki (2008). The argument for locational endurantism given in Gilmore (2007) depends upon the impossibility of mereological coincidence without identity.

problem runs as follows. If region r and object o mereologically coincide (at region r), then they will, presumably, be quite similar (at that region). They will be alike with respect to size and shape. As Hawthorne and Schaffer note, it's plausible that they will be alike with respect to the values of the various fields associated with r. Given these similarities, it may seem o and r should not differ in any way whatsoever.

Some philosophers will be moved by none of these considerations. But those who are moved will want to find an alternative to PCV and MSCV. (I have a special interest in finding such an alternative. For I have given an argument in favor of locational endurantism that relies on the principle that it is impossible for two different objects to mereologically coincide (in Gilmore 2007)).

## 1.5 Third Compromise: Regions-as-Pluralities Multilocationism

Faced with a threat of mereological coincidence between two entities, a natural response is to keep one and eliminate the other. Our third compromise keeps the material objects and eliminates the regions with which they were said to coincide.

Informally, the idea is as follows. There are spatially and temporally unextended, mereologically simple spacetime *points*, and there are *sets* of these points, but there are no mereological sums/fusions of these points: there are no mereologically complex spacetime regions. When we would ordinarily speak of a certain complex region r as being composed of some simple points, the ps, we should instead just speak of the ps plurally (Hudson 2005, 17). Thus, when we would ordinarily say, concerning some material object o, that o occupies r, we should instead say that o occupies the ps, where 'occupies' is treated as a predicate that is non-distributive with respect to its second argument place. And when the 4Per would ordinarily say that o at r is a part of some other material object, o*, at some other complex region, *r** (composed of the p*s), we should instead say that o, at the ps, is a part of o*, at the p*s, where '… at … is a part of … at …' is treated as a predicate that is non-distributive with respect to its second and fourth argument places (at least).

The *monist substantivalist* component of the new view is that a material object o occupies some points, the ps, only if o is (in a sense to be specified) *composed* of the ps. The *locational endurantist* component of the view is that a persisting material object occupies many different pluralities of points, each of them temporally unextended. Putting these pieces together, we can say that there are many different non-overlapping, temporally unextended pluralities of points, the $p_1$s, the $p_2$s, and so on, such that: Obama occupies $p_1$s and is 'temporarily' composed of them, Obama occupies the $p_2$s and is 'temporarily' composed of them, and so on. Thus we retain locational endurantism and monist substantivalism but, having eschewed talk of complex regions, we avoid the commitment to mereologically coinciding entities.

To state this view more precisely, we will need to introduce a new set of definitions, properly restated in plural terms. First, a pair of principles governing the four-place parthood relation that we are taking to be fundamental:

$$(\mathrm{R}_{4P\,plural})\ \forall x_1 \forall yy_1 \left[\exists x_2 \exists yy_2 \left[P^{pl}(x_1, yy_1, x_2, yy_2) \vee P^{pl}(x_2, yy_2, x_1, yy_1)\right] \rightarrow P^{pl}(x_1, yy_1, x_1, yy_1)\right]$$

If $x_1$ at $yy_1$ is part of some $x_2$ at some $yy_2$ or has some $x_2$ at some $yy_2$ as a part, then $x_1$ at $yy_1$ is a part of $x_1$ at $yy_1$.

$$(\mathrm{T}_{4P\,plural})\ \forall x_1 \forall yy_1 \forall x_2 \forall yy_2 \forall x_3 \forall yy_3 \left[\left[P^{pl}(x_1, yy_1, x_2, yy_2) \,\&\, P^{pl}(x_2, yy_2, x_3, yy_3)\right] \rightarrow P^{pl}(x_1, yy_1, x_3, yy_3)\right]$$

If $x_1$ at $yy_1$ is a part of $x_2$ at $yy_2$ and $x_2$ at $yy_2$ is part of $x_3$ at $yy_3$, then $x_1$ at $yy_1$ is a part of $x_3$ at $yy_3$.

These are just plural analogues of $\mathrm{R}_{4P}$ and $\mathrm{T}_{4P}$. I take them to be self-explanatory. Now for the definitions. I use the symbol '$\prec$' for the predicate 'is one of'.[15].

$$(\mathrm{PD1})\ L^{pl}(x_1, yy_1) =_{df} \exists x_2 \exists yy_2 \left[P^{pl}(x_1, yy_1, x_2, yy_2) \vee P^{pl}(x_2, yy_2, x_1, yy_1)\right]$$

'$x_1$ occupies $yy_1$' means 'for some $x_2$ and some $yy_2$, either $x_1$ at $yy_1$ is a part of $x_2$ at $yy_2$ or $x_2$ at $yy_2$ is a part of $x_1$ at $yy_1$.

$$(\mathrm{PD2})\ PATH^{pl}(x, zz) =_{df} \forall z \left[z \prec zz \leftrightarrow \exists yy \left[L^{pl}(x, yy) \& z \prec yy\right]\right]$$

'x has zz as a path' means 'for any z: z is one of zz if and only if there are yy such that: (i) x occupies yy and (ii) z is one of yy'.

$$(\mathrm{PD3})\ ACHR(zz) =_{df} \forall x \forall y\, [[x \prec zz \& y \prec zz \& x \neq y] \rightarrow SPCLK(x, y)]$$

'zz are achronal' means 'for any x and any y, if x is one of zz and y is one of zz and $x \neq y$, then x is spacelike separated from y'.

$$(\mathrm{PD4})\ PERS(x) =_{df} \exists yy \left[PATH^{pl}(x, yy) \& \neg ACHR(yy)\right]$$

'x persists' means 'there are some yy such that: (i) x has yy as a path and (ii) yy are not achronal'

$$(\mathrm{PD5})\ L\text{-}END^{pl}(x) =_{df} PERS(x) \& \forall yy \left[L^{pl}(x, yy) \rightarrow ACHR(yy)\right]$$

'x locationally endures' means '(i) x persists and (ii) for any yy, if x occupies yy, then yy are achronal'.

Locational endurantism can then be stated as the view that at least one material object persists and all persisting material objects locationally endure. To state the remaining components of Regions-as-Pluralities Multilocationism, it will help to have definitions of plural versions of 'overlaps' and 'fuses'.

$$(\mathrm{PD6})\ O^{pl}(x_1, yy_1, x_2, yy_2) =_{df} \exists x_3 \exists yy_3 \left[P^{pl}(x_3, yy_3, x_1, yy_1) \,\&\, P^{pl}(x_3, yy_3, x_2, yy_2)\right]$$

[15] See Linnebo (2012) on 'is one of' and plural quantification. My notation follows his.

(PD7) $F^{pl}(x, s, zz) =_{df} \exists y(y \in s) \& \forall y_1 [y_1 \in s \rightarrow \exists u_1 \exists ww_1 [[y_1 = <u_1, \{w : w \prec ww_1\}>] \& P^{pl}(u_1, ww_1, x, zz)]] \& \forall u_1 \forall ww_1 [P^{pl}(u_1, ww_1, x, zz) \rightarrow \exists y_2 \exists u_2 \exists ww_2 [y_2 \in s \& y_2 = <u_2, \{w : w \prec ww_2\}> \& O^{pl}(u_2, ww_2, u_1, ww_1)]]$

The last definition requires some unpacking. As before, we are taking fusion to be a three-place relation, but now we take it to hold between a thing, a non-empty set of ordered <thing, set of things> pairs, and a plurality (of points). We say that a thing x fuses set s at plurality zz if and only if: (i) s is a non-empty set of ordered pairs, (ii) each of these pairs is such that its first member, at the *members* of its second member, is a part of x, at zz, and (iii) for any object $u_1$ and plurality $ww_1$, if $u_1$ at $ww_1$ is a part of x at zz, then some member $<u_2, \{w : w \prec ww_2\}>$ of s is such that $u_1$ at $ww_1$ overlaps $u_2$ at $ww_2$.

With all these terms in hand, we can give an official statement of our new view as follows.

*Regions-as-Pluralities Multilocationism (RPM)*

*One Parthood*: There is only one fundamental parthood relation, and it holds both among material objects and among spacetime regions.

$4P_{plural}$: The fundamental parthood relation for material objects is a four-place relation expressed by 'x at yy is a part of z at ww', with one slot for the part, one slot for some things (e.g., spacetime points) that are collectively occupied by the part, one slot for the whole, and one slot for some things (e.g., spacetime points) that are collectively occupied by the whole.

*Compositional Nihilism about Regions*: There are no mereologically complex spacetime regions: if $r$ is a spacetime region and x at yy is a part of $r$ at zz, then $x = r$ and, for any w, if w is one of yy or w is one of zz, then $w = r$. In other words, the only cases of parthood holding among spacetime regions are cases in which a region r, at itself, is a part of r, at itself.

*Locational Endurantism*$_{plural}$: Some material objects persist, and all persisting material objects locationally endure, in the sense defined by PD5.

*Objects Fuse Spacetime Points*: For any material object o and spacetime points, zz, if o occupies zz, then o fuses $\{x : \exists y [y \prec zz \& x = <y, \{y\}>\}]$ at zz.

*Unique Fusion*$_{4Pplural}$: For any x, y, s, and zz: if x fuses s at zz and y fuses s at zz, then $x = y$.

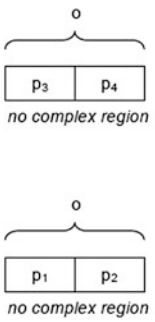
*No Fundamental Occupation*$_{4P}$: There is no fundamental occupation relation; the predicate 'occupies' is defined in terms of 'x at yy is a part of z at ww', as specified in PD1.

*Objects Lack Temporal Parts*: There are material objects, but none of them has proper temporal parts.

*Withinness*$_{4Pplural}$: If x at yy is a part of z at ww, then yy are among ww, i.e., $\forall u [u \prec yy \rightarrow u \prec ww]$

Figure 1.6 depicts a simplified situation in which both RPM and monistic substantivalism are satisfied.

We can think of RPM as a theory of restricted composition, á la Van Inwagen (1990), but applied to spacetime points rather than to 'simple, enduring,




**Some facts about the case**

1. o is a material object, not a spacetime region
2. $p_1 - p_4$ are mereologically simple spacetime regions ('points')
3. There are no other regions; in particular, there are no complex regions made up of $p_1 - p_4$.
4. Each spacetime region occupies$^{pl}$ exactly one spacetime region, itself
5. o occupies$^{pl}$ $p_1$ and $p_2$ (collectively) and o occupies$^{pl}$ $p_3$ and $p_4$ (collectively); o occupies$^{pl}$ nothing else
6. o fuses$^{pl}$ {<$p_1$, {$p_1$}>, <$p_2$, {$p_2$}>} at $p_1$,$p_2$
7. o fuses$^{pl}$ {<$p_3$, {$p_3$}>, <$p_4$, {$p_4$}>} at $p_3$,$p_4$

**Fig. 1.6** Regions-as-pluralities Multilocationism

fundamental particles' such as electrons and quarks. Simplified somewhat, the theory makes the following claims:

(i) for any spacetime points, pp, if there are more than one of pp, then pp compose something if and only if:

  (a) they are achronal, and
  (b) they are arranged R-wise [where R is unspecified so far],

and

(ii) if there are more than one of pp and they do compose some entity o, then:

  (a) o is a material object, not a spacetime region,
  (b) o occupies pp,
  (c) o is the only entity that pp compose,

and

(iii) there are some persisting material objects, each such object occupies more than one plurality of spacetime points, and each such object is composed ('temporarily') of each of the pluralities of spacetime points that it occupies.

The analogy with van Inwagen's position is more than incidental. In (i) above, one could replace 'R' with 'living organism' and the result would be a version of van Inwagen's position that is consistent with monistic substantivalism. (Of course, RPM is flexible enough to accommodate other views about composition as well.) According to the 'van Inwagen-ized' version of RPM, there are mereologically simple spacetime points, living organisms (which are composed of certain pluralities of these points and which are multilocated in spacetime), and no other concrete entities.[16]

[16]Similarly, the dominant-kinds view developed in a dualist-substantivalist context by Burke (1994) and Rea (2000) can be developed in monist-substantivalist context with an appropriate replacement for 'R' in (i). Likewise for virtually any uniqueness-friendly endurantist theory of persistence-and-composition. See Markosian (2008) for more on restricted composition.

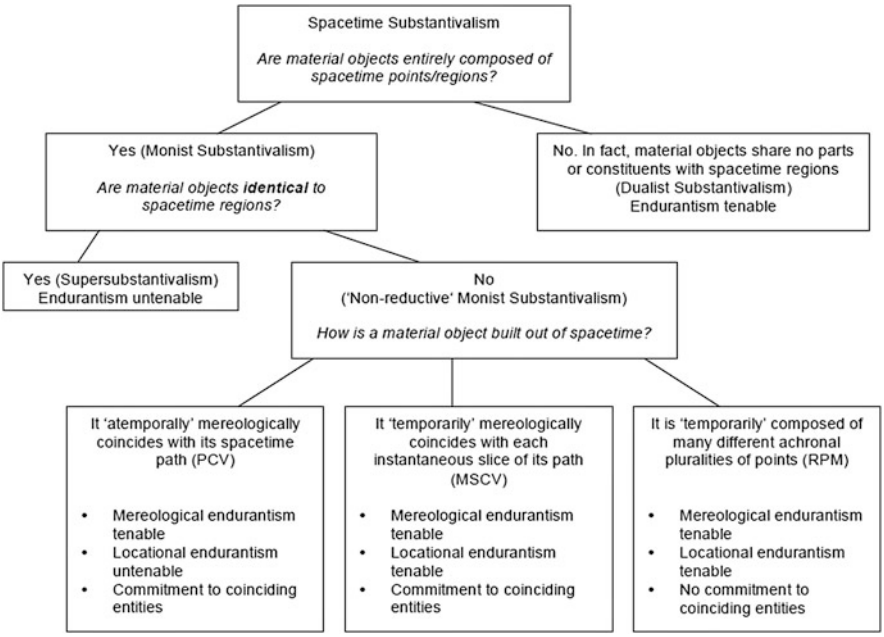



**Fig. 1.7** Spacetime Substantivalism and Endurantism

Admittedly, the van Inwagen-ized version of RPM faces worries about arbitrariness and anthropocentrism. Why privilege living organisms over artifacts or non-living natural formations such as molecules or planets? And it depends upon an assumption which some will doubt: viz., that spacetime ultimately bottoms out in simple spacetime points, rather than being gunky. But these criticisms apply equally to van Inwagen's actual view, a form of dualist substantivalism. (van Inwagen assumes that matter bottoms out in simple particles rather than being gunky.)

Similarly, *any* version of RPM will need to make some maneuver that guarantees that no two material objects ever coincide even temporarily, and any such maneuver will have drawbacks. When I start with a lump-shaped piece of clay and mold it into a statue, it seems that I end up the following thing(s) in my hands: a piece of clay that has existed for several hours at least, and a statue that has existed only for a few minutes. This generates a Leibniz-law argument for the conclusion that the statue and the piece of clay are not identical, despite coinciding mereologically. One might deny the existence of statues and/or lumps (Merricks 2001; Van Inwagen 1990), one might say that a lump ceases to exist when molded into a statue (Burke 1994; Rea 2000), or might find something else to say. Presumably these moves all have their costs. But the crucial point is that RPM is not to blame. Coincidence-deniers already had to make these moves in the context of dualist substantivalism, before RPM came on the scene. (Figure 1.7 summarizes the terrain covered in Sects. 1.2–1.5.)

## 1.6 Two Problems for All Three Compromises

So far I have suppressed a pair of problems that afflict all three compromise positions. To these I now turn.

### *1.6.1 New Chalk*

Judith Jarvis Thomson has offered the following argument against perdurantism:

> [If perdurantism is true, then] as I hold the bit of chalk in my hand, new stuff, new chalk keeps constantly coming into existence ex nihilo. That strikes me as obviously false. Thomson (1983, 213).

This argument is often dismissed as question-begging or otherwise not worth taking seriously. Whether or not such a dismissive attitude is justified, one thing does seem clear: of those philosophers who take perdurantism to be a 'live option' prior to encountering Thomson's argument, few will be convinced by that argument when they are exposed to it. Still, I suspect that, for better or for worse, Thomson's central premise,

> (T) it is not the case that, as I hold a bit of chalk in my hand, new stuff, new chalk keeps constantly popping into existence,

is a deeply held (perhaps basic) commitment for a significant number of endurantists. And if (T) is incompatible with perdurantism, it is also in tension with PCV, MSCV, and RPM. Let me take these in turn.

**PCV and new chalk.** There is logical space to say that this bit of chalk mereologically coincides with its spacetime path, that its path has temporal parts, but that the bit of chalk itself does not. Still, on this view, there are entities (instantaneous temporal parts of the path) that are very much *like* temporal parts of the bit of chalk. Each of them is composed entirely of simples (spacetime points) none of which were present at previous moments. Presumably each of these temporal parts of the bit of chalk have many or all of the same intrinsic physical properties as the bit of chalk (at the relevant times) – so much so that it would be accurate to say that they are 'chalky'. And they keep constantly popping into existence as I hold the bit of chalk in my hand. This conflicts with (T) if perdurantism does. (Strictly speaking, it is not obvious that if perdurantism is true, then new stuff or new chalk keeps popping into existence. This depends on subtle questions about the semantics of mass expressions like 'stuff' and 'chalk'. We cannot address these questions here.)

**MSCV and the new chalk.** The only major difference between MSCV and PCV is that MSCV takes the fundamental parthood relation, and the mereological coincidence relation defined in terms of it, to be relativized to regions. MSCV agrees with PCV that the bit of chalk has a spacetime path, that this path has instantaneous

temporal parts, that these parts are 'chalky', and that they keep constantly popping into existence as I hold the bit of chalk in my hand.

**RPM and the new chalk.** RPM denies the existence of mereologically complex spacetime regions. So it denies that the bit of chalk has a spacetime path that has instantaneous temporal parts. But it still conflicts with the spirit of (T). Roughly put, RPM tells us that as I hold the bit of chalk in my hand at time t1, the bit of chalk is composed of some simple spacetime points, the p1s, and a few seconds later, at t2, the bit of chalk is composed of some other simple spacetime points, the p2s, where none of the p1s is identical to any of the p2s. Indeed, according to RPM (and PCV and MSCV too), there is a clear sense in which, between any two instants (in the same frame of reference), the bit of chalk undergoes *complete mereological turnover* at the fundamental level, the level of simples. There may not be any new *complex entities* popping into existence, but at each moment, there is an entirely new *plurality of simples* that pop into existence (and that compose the bit of chalk). Does this force us to say that *new stuff* or *new chalk* pops into existence? Again, this depends on questions about the semantics of mass expressions that I cannot address here. But either way, RPM surely conflicts with the spirit of (T), if perdurantism does.

Of course, the endurantist who embraces *dualist* substantivalism does not face the problem about new chalk. Since he denies that material objects share any parts or constituents with spacetime, he is free to say that the bit of chalk undergoes *no mereological variation at all*. For example, he is free to say that it is composed of some simple, fundamental particles, the ps, at t1, and that it is composed of these very same simple particles at t2.

### *1.6.2 Spatially Point-Like Enduring Objects*

Interestingly, the existence of spatially point-like material objects would wreak havoc on all three compromise positions.[17] We can take them in turn once again.

**PCV and spatially point-like material objects.** Let e be a spatially point-like persisting material object, with a (one-dimensional) timelike curve as a spacetime path. Since's e's path is a timelike curve, the instantaneous temporal parts of that path are simple spacetime points. So, since e mereologically coincides with this path, these points are parts of e too. (Mereologically coincident objects may be able to differ with respect to their *complex* parts, but, given that parthood is reflexive, they

[17] And if spacetime is composed of spatially extended simple 'grains', the existence of 'spatially-grain-like' material objects would be equally problematic for all three compromise positions, for parallel reasons.

cannot differ with respect to their *simple* parts.[18]) But if the given points are parts of e, they are instantaneous temporal parts of e. So e has *instantaneous temporal parts*: it mereologically perdures. Thus PCV loses its appeal for the endurantist.

**MSCV and spatially point-like material objects.** The Many-Slice Constitution View does not say that e mereologically coincides with its path. Rather, it says that e mereologically coincides, in the '4P-appropriate way', with each instantaneous slice of that path. As I noted above, each of those slices is just a simple spacetime point. So, according to MSCV, e mereologically coincides with each in a series of simple points, without being identical to any of those points. But this is problematic. As I have noted elsewhere (forthcoming), the claim that

(3) e mereologically coincides with a simple to which it is not identical

is inconsistent with the reflexivity of parthood together with a plausible supplementation principle, 'quasi-supplementation':

(*QS*) if x is a part of y and x is not identical to y, then y has parts z and z* that do not overlap each other.

(Similarly, the '4P-appropriate' version of (3) is inconsistent with the 4P-appropriate versions of reflexivity and *QS*, taken together.) The bottom line is that if *QS* and the reflexivity of parthood are both necessary truths, then, while it may be possible for two different *complex* objects to coincide with one another, it is not possible for a *simple* object to coincide with any other object. This gives the friend of MSCV a reason to hope that there are no spatially point-like material objects.

**RPM and spatially point-like material objects.** The problem is essentially the same for RPM. Roughly put, RPM says that e is composed, at each moment of its career, of a different achronal plurality of simple spacetime points. In the case of a spatially extended material object, each of the given pluralities would include more than one point. But in the case of a spatially point-like object such as e, each of the given 'pluralities' includes just one thing, a simple point. So, at each moment of its career, e is composed of some simple (non-persisting) spacetime point – with which e is not identical. This is inconsistent with the conjunction of the relevant versions of the reflexivity of parthood and *QS*.

[18]We will assume that (i) x and y mereologically coincide, (ii) z is simple, and (iii) z is a part of x; we will show that z is a part of y, too. By (i) and the definition of 'mereologically coincide', it follows that (v) x and y overlap exactly the same things. By the reflexivity of parthood, (vi) z is a part of itself. Together with (iii) and the definition of 'overlaps', this entails that (vii) x overlaps z. Together with (v), this entails that y overlaps z. So, by the definition of 'overlap', (viii) there is a thing, call it w, that is a part of z and a part of y. But by the definition of 'simple', the only part of z is z itself. So w=z, and hence z is a part of y.

## 1.7 Conclusion

Of those who work on the metaphysics of persistence, most seem to assume that only perdurantists can build material objects out of spacetime. But the situation is not so straightforward.

If one is willing to embrace coinciding entities and reject Strong Supplementation, one can say that material objects lack temporal parts even though they coincide with temporally extended regions that have temporal parts. (This is the Path Constitution View, PCV.) Indeed, one can get this far while confining oneself to the *perdurantist*'s attractively simple fundamental ideology – a primitive two-place predicate for parthood *simpliciter*.

If one is willing to go a bit farther and help oneself to a slightly more exotic piece of fundamental ideology (a primitive, more-than-two-place predicate for a 'location-relative' parthood relation), and if one is still willing to embrace coinciding objects and reject Strong Supplementation, then one can say that material objects both (i) lack temporal parts, in the manner of 'mereological endurantism', and (ii) are multilocated in spacetime, in the manner of 'locational endurantism'. (This is the Many-Slice Constitution View, MSCV.) It is worth repeating, however, that virtually all eternalistic, B-theoretic endurantists already help themselves to a fundamental relativized parthood predicate, even in the context of dualist substantivalism.

Finally, if one is willing to eliminate complex spacetime regions (in favor of sets or pluralities of points) and treat the fundamental parthood predicate as being not merely 'location-relative' but also non-distributive, one can (i) reject temporal parts, (ii) retain locational endurantism, and (iii) avoid coinciding entities. (This is Regions-as-Pluralities Multilocationism, RPM.)

However, all three views come with further costs. They are all subject to Thomson-esque worries about 'new chalk' constantly popping into existence. And none of them fits well with the view that there are spatially point-like material objects. But for the would-be endurantist who is impressed by the case against dualist substantivalism, all this may be a price worth paying.

## References

Balashov, Y. (2010). *Persistence and spacetime*. Oxford: Oxford University Press.

Bennett, K. (2004). Spatiotemporal coincidence and the grounding problem. *Philosophical Studies, 118*(3), 339–371.

Braddon-Mitchell, D., & Miller, K. (2006). The physics of extended simples. *Analysis, 66*, 222–226.

Burke, M. (1994). Preserving the principle of one object to a place: a novel account of the relations among objects, sorts, sortals and persistence conditions. *Philosophy and Phenomenological Research, 54*, 591–624.

Dainton, B. (2010) *Time and space* (2nd ed.). Montreal: McGill-Queen's.

Donnelly, M. (2010). Parthood and multi-location. In D. Zimmerman (Ed.), *Oxford studies in metaphysics* (Vol. 5, pp. 203–243).

Eagle, A. (2010). Perdurance and location. In D. Zimmerman (Ed.), *Oxford studies in metaphysics* (Vol. 5, pp. 53–94). Oxford: Oxford University Press.
Earman, J. (1989). *World enough and spacetime*. Cambridge: MIT.
Gibson, I. & Pooley, O. (2006). Relativistic persistence. In J. Hawthorne (Ed.), *Philosophical Perspectives, 20*, 157–198.
Gilmore, C. (forthcoming). Quasi-supplementation, plenitudinous coincidentalism, and gunk. In R. Garcia (Ed.), *Substance: New essays*. Philosophia Verlag.
Gilmore, C. (2006). Where in the relativistic world are we? In J. Hawthorne (Ed.), *Philosophical perspectives: metaphysics* (Vol. 20, pp. 199–236). Oxford: Blackwell.
Gilmore, C. (2007). Time travel, coinciding objects, and persistence. In D. Zimmerman (Ed.), *Oxford studies in metaphysics* (Vol. 3, pp. 177–198). Oxford: Oxford University Press.
Gilmore, C. (2008). Persistence and location in relativistic spacetime. *Philosophy Compass, 3/6*, 1224–1254.
Gilmore, C. (2009). Why parthood might be a four place relation, and how it behaves if it is. In L. Honnefelder, E. Runggaldier, & B. Schick (Eds.), *Unity and time in metaphysics* (pp. 83–133). Berlin: de Gruyter.
Haslanger, S. (2003). Persistence through time. In M. J. Loux & D. W. Zimmerman (Eds.), *The Oxford handbook of metaphysics*, (pp. 315–354). Oxford: Oxford University Press.
Hawthorne, J. (2006). *Metaphysical essays*. Oxford: Oxford University Press.
Hawthorne, J., & Sider, T. (2006). Locations. In J. Hawthorne (Ed.), *Metaphysical essays*, (pp. 85–109). Ithaca: Oxford University Press.
Hershenov, D. (2005). Do dead bodies pose a problem for biological approaches to personal identity? *Mind, 114*, 31–59.
Hudson, H. (2001). *A materialist metaphysics of the human person*. Ithaca: Cornell University Press.
Hudson, H. (2005) *The metaphysics of hyperspace*. Oxford: Oxford Univerty Press.
Kleinschmidt, S. (2011). Multilocation and mereology. *Philosophical Perspectives, 25*(1), 253–276. J. Hawthorne (Ed.).
Koslicki, K. (2008). *The structure of objects*. Oxford: Oxford University Press.
Linnebo, Ø. (2012). Plural quantification. In E. N. Zalta (Ed.), *The Stanford encyclopedia of philosophy* (Spring 2013 ed.). http://plato.stanford.edu/archives/spr2013/entries/plural-quant/
Lowe, E. J. (2003). Substantial change and spatiotemporal coincidence. *Ratio, 16*, 140–160.
Markosian, N. (2008). Restricted composition. In T. Sider, J. Hawthorne, & D. W. Zimmerman (Eds.), *Contemporary debates in metaphysics*, (pp. 341–363). London: Blackwell.
Markosian, N. (2010). Time. In E. N. Zalta (Ed.), *The Stanford encyclopedia of philosophy* (Spring 2014 ed.). http://pluto.stanford.edu/archives/spr2014/entries/time/
McDaniel, K. (2004). Modal realism with overlap. *Australasian Journal of Philosophy, 82*, 137–152.
McGrath, M. (2007). Four-dimensionalism and the puzzles of coincidence. In D. Zimmerman (Ed.), *Oxford studies in metaphysics* (Vol. 3, pp. 143–176). Oxford: Oxford University Press.
Merricks, T. (2001). *Objects and persons*. Oxford: Oxford University Press.
Olson, E. (1997). *The human animal: Personal identity without psychology*. Oxford: Oxford University Press.
Parsons, J. (2000). Must a four-dimensionalist believe in temporal parts? *The Monist, 83*, 399–418.
Parsons, J. (2007). Theories of location. In D. W. Zimmerman (Ed.), *Oxford studies in metaphysics*, (Vol. 3, pp. 201–232). Oxford: Oxford University Press.
Rea, M. (1998). In defense of mereological universalism. *Philosophy and Phenomenological Research, 58*(2), 347–360.
Rea, M. (2000). Constitution and kind membership. *Philosophical Studies, 97*, 169–193.
Schaffer, J. (2009). Spacetime the one substance. *Philosophical Studies, 145*, 131–148.
Sider, T. (2001). *Four-dimensionalism: An ontology of persistence and time*. Oxford: Clarendon.
Thomson, J. J. (1983). Parthood and identity over time. *Journal of Philosophy, 80*, 201–220.
Van Inwagen, P. (1990). *Material beings*. Ithaca: Cornell University Press.