

## 8. Parthood and Location\*

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### 1. INTRODUCTION: TWO VARIETIES OF MEREOLOGICAL MISMATCHING

The material world has a mereological structure. One may disagree about what that structure looks like—one may think, for instance, that any material things make up a whole, or that only some or even none of them do; that some material things have parts all the way down, or that none of them do; etc. But no one would deny that the material world has some mereological structure or other—part-whole relations organize material things somehow or other. Spacetime, too, has a mereological structure. There may also be disagreements about the makeup of that structure—as with material things, one may think that any regions make up a region, or that only some or even none of them do; that some regions have subregions all the way down, or that none of them do; etc. But, as with the material world, no one would deny that spacetime has some mereological structure or other—spacetime regions are arranged into part-whole relations somehow or other. On the other hand, the material world is located in spacetime. One may also disagree about the nature of that connection—one may think, for instance, that no spacetime region has more than one occupant, or that some of them do; that no material thing has more than one location, or that some of them do; etc. But no one would deny that the material world is located in spacetime somehow or other—location relations tie material things to regions of spacetime in some way or

\* Many thanks to Andrea Borghini, Louis deRosset, Kit Fine, Greg Fowler, Katherine Hawley, John Hawthorne, Hud Hudson, Dan Korman, Dave Liebesman, Ned Markosian, Kris McDaniel, Thomas Sattig, Jonathan Schaffer, Ted Sider, Alex Skiles, Joshua Spencer, Zoltán Szabó, Gabriel Uzquiano, Dave Van Bruwaene, Achille Varzi, Andrew Wake, Brian Weatherston, Robbie Williams, and Briggs Wright for valuable discussion and comments on previous drafts. Special thanks to Karen Bennett, Matti Eklund, Nico Silins, and Dean Zimmerman for a lot of patience and extensive feedback on several drafts.

another. These basic facts about the material world and spacetime give rise to an interesting issue. Given that the material world is located in spacetime, how are their mereological structures related to one another? Is it metaphysically necessary that those structures perfectly align, or is it possible that they somehow mismatch? If they must perfectly align, what explains that necessity? And if it is possible that they somehow mismatch, what sorts of disparities are possible, and why?<sup>1</sup>

Here's one way in which those structures may fail to perfectly align: there may be a mismatch between the part-whole structure of a material thing and the part-whole structure of the region of spacetime at which that thing is located. Material things that are mereologically simple but that are located at mereologically complex regions would be one example of this sort of misalignment.<sup>2</sup> For other examples, consider mereologically complex material objects that are located at mereologically simple regions, gunky material objects that are located at non-gunky regions, and non-gunky

<sup>1</sup> Three assumptions about mereological and location relations I will be making in what follows. First, I take as undefined the parthood relation of classical mereology—parthood is a partial order that does not hold relative to times, places, worlds, sorts, or anything else. I take other mereological relations (proper parthood, overlap, composition, etc.) to be defined in terms of parthood in the usual way. Second, I assume that the subregion relation among regions of spacetime is just the parthood relation restricted to such regions. Third, I take as undefined the location relation that Josh Parsons (2007) calls *exact* location. This is an unrelativized two-place location relation that holds between material things and regions of spacetime, on which a material thing counts as exactly located at only one region, *i.e.* the region that is like the thing's "shadow" in substantial spacetime. Along with Parsons, I will assume that this relation is a total function on material objects—every material thing has exactly one exact location. So we may speak of *the* exact location of a material thing, or of a material thing's exact location. Other location relations (*e.g.* what Parsons calls *weak*, *entire*, and *persuasive* location) may be defined in terms of this relation. For simplicity's sake, however, when I talk about location in an unqualified manner in what follows, I will mean exact location. (I should note that in fact all these assumptions are merely for simplificatory purposes. Everything I will say here is compatible with *e.g.* relativizing mereological and location relations to times and taking location relations to hold among material things and regions of space, not spacetime. Moreover, the more substantive of these assumptions will be explicitly called into question at the end of §5 below. So even if you find them objectionable or somehow inadequate, let me hang on to them for the time being.)

<sup>2</sup> A material thing/region is mereologically simple just in case it has no proper parts/subregions, and is mereologically complex just in case it isn't mereologically simple.

material objects that are located at gunky regions.<sup>3</sup> I call disparities of the sort involved in these cases *internal disparities*, since they concern the internal mereological structure of material things and their locations.

A bit more generally, internal disparities occur when biconditionals such as the following are violated in one or the other direction (all indented claims hereon are universally quantified over material things unless otherwise noted):

- (1)  $x$  is mereologically simple iff  $x$ 's location is mereologically simple.
- (2)  $x$  is mereologically complex iff  $x$ 's location is mereologically complex.
- (3)  $x$  has exactly  $n$  parts iff  $x$ 's location has exactly  $n$  subregions.<sup>4</sup>
- (4)  $x$  is gunky iff  $x$ 's location is gunky.

I call biconditionals of this sort *internal alignment principles*. Characterizing cases of internal disparities as cases violating internal alignment principles makes it clear that they involve situations in which either the part-whole structure of a material thing fails to be preserved onto that thing's location, or the part-whole structure of a material thing's location fails to be preserved onto that thing.

There is, however, another way in which the mereological structure of the material world and that of spacetime may fail to perfectly align. Here the mismatch is not between the mereological structure of a material thing and the mereological structure of that thing's location, but between the mereological relations on some material things and the mereological relations on those things' locations. Disparities of this sort occur when biconditionals like the following are violated in one or the other direction:

- (5)  $x$  is part of  $y$  iff  $x$ 's location is a subregion of  $y$ 's location.
- (6)  $x$  is proper part of  $y$  iff  $x$ 's location is a proper subregion of  $y$ 's location.

<sup>3</sup> A gunky material thing/region is one every part/subregion of which has proper parts/subregions.

<sup>4</sup> The attentive reader will notice that, given the definitions of mereological simplicity and complexity, (1) and (2) are logically equivalent, and that they are equivalent to an instance of (3), *i.e.* the  $n = 1$  instance (remember that parthood is reflexive). I have listed these principles separately for the reader to get a better grasp of what's at issue in cases of internal disparities.

- (7)  $x$  and  $y$  overlap iff  $x$ 's location and  $y$ 's location overlap.
- (8) The  $x$ s compose  $y$  iff the locations of the  $x$ s compose  $y$ 's location.

Cases violating these principles thus involve situations in which either the mereological relations on some material things fail to be preserved onto those things' locations, or the mereological relations on some material things' locations fail to be preserved onto those things. I call disparities violating these principles *external disparities*, since they concern external mereological relations among material objects and their locations, regardless of what their internal mereological structures may be. Correspondingly, I call biconditionals like the above *external alignment principles*.<sup>5</sup>

What's the connection between these two varieties of mereological mismatching? If there are internal disparities, must there be external ones? And if there are external disparities, must there be internal ones? The answer to both of these questions is *no*. First, for a situation with internal but no external disparities, suppose that there is exactly one material thing, that such a thing is a simple, and that it is located at a complex region. Then the mereological structure of some material thing and the mereological structure of that thing's location fail to perfectly align—the simple has no proper parts, but its location has proper subregions. But all the mereological relations on any material things and their locations are nonetheless fully preserved in both directions—no external alignment principle is violated. So internal disparities do not require external ones.

Second, for a situation with external but no internal disparities, suppose that there are exactly two material objects, that each of those things is a simple, and that they are co-located at a simple region. Here the part-whole structure of every material thing perfectly matches that of its location—no internal alignment principle is violated. But various mereological relations on some material objects' locations fail to be preserved onto those objects. That is,

<sup>5</sup> These principles were independently articulated by Gabriel Uzquiano (this volume). Uzquiano calls them principles of mereological *harmony*, echoing a suggestive label due to Jonathan Schaffer (2009b). I will stick to my label instead of adopting this one, given that there are in fact two notions of harmony in the neighborhood (internal and external), which are, as we will see below, logically independent from one another.

the right-to-left direction of various external alignment principles is violated: the locations of the simples are subregions of one another, but neither simple is part of the other; the locations of the simples have subregions in common, but the simples have no parts in common; the locations of the simples compose the location of either simple, but the simples compose neither simple. So external disparities do not require internal ones.

It follows that the distinction between our two varieties of mereological mismatching is far from superficial—they are logically independent from one another. So, at least in principle, one may accept the metaphysical possibility of internal disparities without accepting the metaphysical possibility of external ones, and the other way around.<sup>6</sup>

This suggests that the general issue of whether it is metaphysically possible that the part-whole structure of the material world and the part-whole structure of spacetime fail to perfectly align breaks down into two more specific, independent issues. The first one is whether internal disparities are metaphysically possible. If so, what forms of internal disparities are possible, and what grounds their possibility? Otherwise, what explains the necessity of internal alignment principles? The second issue is whether external disparities are metaphysically possible. If so, what forms of external disparities are possible, and what grounds their possibility? Otherwise, what explains the necessity of external alignment principles?

The first issue has received a fair share of attention in the recent literature. It has not been raised as explicitly or in the full generality in which we may now appreciate it, nor has it been distinguished from the second one. Nonetheless, metaphysicians have widely discussed, for instance, whether it is metaphysically possible that simple material objects be located at complex regions, *i.e.* whether violations to the left-to-right direction of (1) are possible (see *e.g.* Markosian 1998, 2004; Parsons 2000; McDaniel 2007a, 2007b; Sider 2007).<sup>7</sup> The possibility of other forms of internal disparities has also

<sup>6</sup> Of course, this general point is compatible with there being connections between *specific* forms of internal and external disparities. For instance, Uzquiano (this volume) effectively argues that certain forms of internal disparities require certain forms of external ones.

<sup>7</sup> More precisely, what has been widely discussed is the possibility of *extended* material simples, *i.e.* material things that have no proper parts but are located at extended regions. Although, of course, one may think that not all extended regions

been discussed in the literature, if to a lesser extent (*e.g.* McDaniel 2007a, 2006; Hudson 2007).

By contrast, the second issue has received virtually no attention in the literature—whether external disparities are metaphysically possible has not been addressed or even entertained.<sup>8</sup> My aim here is to fill this gap: I will be concerned with whether certain particularly counterintuitive cases of external disparities are metaphysically possible. I will argue that their possibility follows from otherwise plausible assumptions about the nature of mereological and location relations, together with an otherwise plausible recombination principle. This is in fact the main kind of argument that has been given in favor of the possibility of internal disparities: McDaniel (2007b) and Sider (2007) argue that the possibility of material simples with complex locations may be established on combinatorial grounds, and McDaniel (2006) argues that the same holds for the possibility of complex material objects with simple locations, as well as for the possibility of gunky material objects with non-gunky locations. What I will suggest here is that this kind of argument cuts much deeper than that—it generalizes to support the possibility of the highly counterintuitive cases of external disparities I am interested in. I will argue, however, that the specific combinatorial argument from which the possibility of external disparities follows is otherwise pretty well-behaved, in that it does *not* generalize for other contentious possibilities concerning mereology and location, such as that parthood may fail to be transitive for either material objects or regions, that gunky material objects or regions are possible, that co-located material objects are possible, that internal disparities are possible, etc. Moreover, I will argue that resisting the argument leaves us with a choice of equally unappealing alternatives, and so that tollensing it comes at a higher cost than one might have thought. In addition, I will suggest that whether these cases of external disparities are possible is not an isolated curiosity—it has illuminating connections to a number of other metaphysical debates.

have proper subregions, the possibility of extended simples is often considered under the assumption that their locations *do* have proper subregions.

<sup>8</sup> Moreover, save for Uzquiano's parallel work on the matter (this volume), principles like (5)–(8) have not been explicitly articulated or discussed before.

A roadmap of the paper. In §2, I characterize in a bit more detail the cases of external disparities that I will concentrate on. In §3, I identify the recombination principle that, together with the relevant assumptions about mereological and location relations, requires that such misalignments be metaphysically possible. In §4, I show *how exactly* the possibility of such misalignments follows from that recombination principle and those assumptions, and explain why the argument does not generalize for other controversial possibilities. In §5, I argue that resisting the possibility of such misalignments requires equally unattractive alternatives. Finally, in §6, I discuss how their possibility is connected to other debates in metaphysics.

## 2. PARTHOOD VS. CONTRACTION, COMPOSITION VS. EXPANSION

Above I talked about two sorts of relations: mereological relations, which connect material things to material things and spacetime regions to spacetime regions, and location relations, which connect material things to spacetime regions. It will be useful to explicitly introduce a third family of relations, which connect material things to material things. First, let's say that a material thing,  $x$ , is a *contraction* of a material thing,  $y$ , iff  $x$ 's location is a subregion of  $y$ 's location, *i.e.* iff  $x$  is located at a subregion of the region at which  $y$  is located. So my head, for instance, counts as a contraction of my head, my body, and the top half of my body, but not of my nose, the right half of my body, the left half of my body, or the bottom half of my body. Second, let's say that  $x$  is a *proper contraction* of  $y$  iff  $x$  is a contraction of  $y$  but  $y$  is not a contraction of  $x$ . My head then counts as a proper contraction of my body and the top half of my body, but not of my head, my nose, the right half of my body, the left half of my body, or the bottom half of my body. Third, let's say that some material things, the  $x$ s, *expand into* a material thing,  $y$ , iff the locations of the  $x$ s compose  $y$ 's location; this will be the same as saying that  $y$  is an *expansion* of the  $x$ s.<sup>9</sup> So my body counts as an

<sup>9</sup> It's important to note that to say that a material thing is an expansion of some material objects is *not* to say that each of those objects is a contraction of that thing, and every contraction of that thing has a contraction in common with at least one of those objects. The latter condition is not equivalent to saying that every subregion of

expansion of the right and left halves of my body, as well as of my head, the right half of my body, and the top and bottom halves of my body, but not of the top and right halves of my body, nor of my head, my nose, and the bottom half of my body.<sup>10</sup>

Notice that this is a family of *spatiotemporal* relations—they concern where in spacetime material things are located. Contraction, proper contraction, and expansion connect material things to one another on the basis of their spatiotemporal location; more particularly, they connect them to one another on the basis of what mereological relations hold among their locations. Moreover, they do so *solely* on that basis. If you wanted to specify how this family of relations is distributed over some material things, it would be necessary and sufficient to specify where in spacetime they are located; in particular, it would be necessary and sufficient to specify how their locations are mereologically related to one another.<sup>11</sup>

Now, given this family of spatiotemporal relations among material things, it's clear that (5) is equivalent to the following principle, according to which in order for a material thing to be part of another it is both necessary and sufficient that it be a contraction of the other:

(Parthood  $\Leftrightarrow$  Contraction)  $x$  is part of  $y$  iff  $x$  is a contraction of  $y$ .

that thing's location overlaps at least one of those objects' location, which is what the definition of an expansion requires.

<sup>10</sup> I loosely borrow the contraction/expansion terminology from Sider (2007). I say 'loosely' because Sider's notion of an expansion differs from mine in two important respects. First, he thinks that expansion is a relation that single things bear to single things, not that pluralities of things bear to single things. Second, he takes a thing to be an expansion of another iff the latter is a contraction of the former. So even constrained to pluralities of only one thing, my notion of an expansion is much stronger than his.

<sup>11</sup> Of course, contraction, proper contraction, and expansion do not exhaust this family of spatiotemporal relations (consider *e.g.* a relation that holds among a pair of material things iff their locations overlap, or iff their locations underlap, and so on). For my purposes here, however, we need not give a name to other relations in this family. It is also worth noting that this family of spatiotemporal relations does not exhaust *all* spatiotemporal relations that may hold among some material things. Distance relations, for instance, may not be accounted for in terms of them (at least not without further assumptions). For simplicity, however, when I talk about spatiotemporal relations in an unqualified manner in what follows, I will mean this specific class of spatiotemporal relations.

Similarly, (8) is equivalent to the following principle, according to which in order for some material things to compose another it is both necessary and sufficient that they expand into it:

(Composition $\Leftrightarrow$ Expansion) the  $xs$  compose  $y$  iff the  $xs$  expand into  $y$ .

And so (8) and Composition $\Leftrightarrow$ Expansion are equivalent to a principle according to which in order for a material thing to be a fusion of some material objects it is both necessary and sufficient that it be an expansion of those objects, *i.e.* to a principle claiming that  $y$  is a fusion of the  $xs$  iff  $y$  is an expansion of the  $xs$ .

Principles like Parthood $\Leftrightarrow$ Contraction and Composition $\Leftrightarrow$ Expansion explicitly claim that in order for some material things to stand in certain *mereological* relations to one another it is necessary and sufficient that they stand in certain *spatiotemporal* relations to one another; equivalently, they claim that in order for some material things to bear certain spatiotemporal relations to one another it is both necessary and sufficient that they bear certain mereological relations to one another. And since these principles linking mereology and spatiotemporality are equivalent to principles like (5) and (8), this suggests that there are two equivalent ways of thinking about external alignment principles: as principles requiring that the mereological relations on some material things and the mereological relations on those things' locations perfectly align, and as principles requiring that the mereological relations on some material things and the spatiotemporal relations on those things perfectly align. For to say that the mereological relations on some material things and their locations perfectly align is just to say that the mereological and spatiotemporal relations on those things perfectly align; to say *e.g.* that parthood is preserved between material things and their locations in one or the other direction is just to say that parthood and contraction mirror one another in one or the other direction. Correspondingly, there are two equivalent ways of thinking about cases of external disparities: as cases in which there is a mismatch between the mereological relations on some material things and the mereological relations on those things' locations, and as cases in which there is a mismatch between the mereological relations on some material things and the spatiotemporal relations on those

things. Put another way: we may think of external disparities as misalignments of a certain sort between the mereological structures of material world and spacetime, or as misalignments of a certain sort between two structures of the material world itself, *i.e.* its mereological structure and its spatiotemporal structure. To say *e.g.* that composition fails to be preserved between some material things and their locations in one or the other direction is just to say that composition and expansion fail to mirror one another in one or the other direction.

The specific cases of external disparities I will focus on here are precisely ones in which both (5) and (8) are violated in both directions, *i.e.* in which both parthood and composition fail to be preserved both from some material things to their locations, and from some material things' locations to those things. In light of the above, these are cases in which both Parthood $\Leftrightarrow$ Contraction and Composition $\Leftrightarrow$ Expansion are violated in both directions, *i.e.* in which there is a two-way mismatch between parthood and contraction as well as between composition and expansion. Let's look at these cases in a bit more detail.

First, notice that Composition $\Leftrightarrow$ Expansion is stronger than Parthood $\Leftrightarrow$ Contraction: Composition $\Rightarrow$ Expansion entails Parthood $\Rightarrow$ Contraction, and Expansion $\Rightarrow$ Composition entails Contraction $\Rightarrow$ Parthood. For, on the one hand, if  $x$  is part of  $y$ , then, by the definition of composition,  $x$  and  $y$  compose  $y$ . By Composition $\Rightarrow$ Expansion,  $x$  and  $y$  expand into  $y$ . But then, by the definitions of expansion and contraction,  $x$  is a contraction of  $y$ . On the other hand, if  $x$  is a contraction of  $y$ , then, by the definitions of expansion and contraction,  $x$  and  $y$  expand into  $y$ . By Expansion $\Rightarrow$ Composition,  $x$  and  $y$  compose  $y$ . So, by the definition of composition,  $x$  is part of  $y$ . This means that the cases of external disparities that I'll be concerned with here are connected—cases violating either direction of Parthood $\Leftrightarrow$ Contraction are also cases violating the corresponding direction of Composition $\Leftrightarrow$ Expansion. Put another way: if parthood fails to be preserved either from some material things to their locations, or from some material things' locations to those things, then composition fails to be preserved, too, in the corresponding direction. Equivalently: if there is a mismatch between parthood and contraction in either direction,

then there is also a mismatch between composition and expansion in the corresponding direction.

Second, it's important to distinguish  $\text{Contraction} \Rightarrow \text{Parthood}$  from the following principle:

(Partition) For every subregion of  $x$ 's location, there exists a part of  $x$  that is located at that region.

Clearly,  $\text{Contraction} \Rightarrow \text{Parthood}$  does not entail Partition. More interestingly, the converse doesn't hold either— $\text{Contraction} \Rightarrow \text{Parthood}$  follows from Partition only if co-located material objects are ruled out. By the same token,  $\text{Contraction} \Rightarrow \text{Parthood}$  is logically independent from the so-called doctrine of arbitrary undetached parts (DAUP) (van Inwagen 1981):

(DAUP) For any subregion,  $S$ , of  $x$ 's location, if it is metaphysically possible that some material object be located at  $S$ , then there exists a part of  $x$  that is located at  $S$ .

That  $\text{Contraction} \Rightarrow \text{Parthood}$  is independent from both Partition and DAUP is important. It helps clarify what exactly  $\text{Contraction} \Rightarrow \text{Parthood}$  claims, and distinguishes it from other principles floating around in the literature. In particular, it makes it clear that cases violating  $\text{Contraction} \Rightarrow \text{Parthood}$  need not violate either Partition or DAUP.

Now, violations of either direction of either  $\text{Parthood} \Leftrightarrow \text{Contraction}$  or  $\text{Composition} \Leftrightarrow \text{Expansion}$  are highly counter-intuitive—they require the existence of *very* exotic sorts of material objects, which are mereologically and spatiotemporally related in completely dissonant ways. This is most evident in cases violating  $\text{Parthood} \Rightarrow \text{Contraction}$  and hence  $\text{Composition} \Rightarrow \text{Expansion}$ . Such cases involve material things that have parts that are not contractions of them, *i.e.* parts that are located at regions that are not subregions of their locations. So these are material things that have parts 'outside' of them, or not 'contained' within them, spatiotemporally speaking. Put another way, these are things that spatiotemporally 'splurge out'. It's important to distinguish them, however, from other sorts of material objects that may also be thought to spatiotemporally splurge out, such as scattered objects. Scattered objects—as they have been traditionally

understood anyway—are material things with discontinuous locations, *i.e.* material things that are located at regions composed of a plurality of regions at least one of which has no boundaries in common with the rest (cf. Cartwright 1975). To see how such things differ from the kind of material objects violating Parthood $\Rightarrow$ Contraction and Composition $\Rightarrow$ Expansion, consider some arbitrary material things, the *x*s. Assume that at least one of the *x*s is located at a region that has no boundaries in common with the location of any other of the *x*s, and let *S* be the discontinuous region that the locations of the *x*s compose. Now let *y* be a material thing that is composed of the *x*s and that is located at *S*, and let *z* be a material thing that is a fusion but not an expansion of the *x*s. It follows that *y* is a scattered object—it is located at a discontinuous region, *i.e.* *S*. Nonetheless, *y* is an expansion of the *x*s—it is located at the fusion of the regions at which the *x*s are located and so has each of the *x*s as a contraction. By contrast, *z* is not an expansion of the *x*s—by definition, it cannot have each of the *x*s as a contraction, and so cannot be located at *S*. Instead, it must be located at a region that has *S* as a proper subregion, or that is a proper subregion of *S*, or that overlaps *S* but is neither a proper subregion of *S* nor has *S* as a proper subregion, or that fails to overlap *S* altogether. *z*'s location need not even be discontinuous.

One may think that material things involved in cases violating Contraction $\Rightarrow$ Parthood and Expansion $\Rightarrow$ Composition pale by comparison to the ones above. In fact, it is tempting to think that these ones are not really all that exotic. For instance, consider the example I gave in §1 above to illustrate that external disparities do not require internal ones, in which two material simples are co-located at a simple region. This is a case violating Contraction $\Rightarrow$ Parthood and hence Expansion $\Rightarrow$ Composition—both simples in this situation are both contractions and expansions of one another, but neither of them is part of the other, or a fusion of the two. But this is just an old-fashioned case of co-located material objects, only one where those objects and their locations all happen to be simple.

There are, however, violations of Contraction $\Rightarrow$ Parthood and Expansion $\Rightarrow$ Composition that make the oddity of the cases at

issue more apparent. Consider the following principle, according to which in order for a material thing to be a proper part of another it is sufficient that it be a proper contraction of it:

(Proper-Contraction $\Rightarrow$ Proper-Parthood)

$x$  is a proper contraction of  $y$  only if  $x$  is a proper part of  $y$ .

By the definition of proper contractions, this principle is equivalent to the right-to-left direction of (6), and is weaker than Contraction $\Rightarrow$ Parthood and hence than Expansion $\Rightarrow$ Composition. This means that violations of this claim are also violations of Contraction $\Rightarrow$ Parthood, and hence of Expansion $\Rightarrow$ Composition. However, no such violations may involve co-location—by definition they cannot involve two or more material things sharing their location. So they differ from cases like the one of the two co-located simples mentioned above.

Violations of Proper-Contraction $\Rightarrow$ Proper-Parthood involve material things that are not parts of others, but that are nonetheless located at proper subregions of their exact locations. So they involve the existence of things that are “inside” or “contained” within others spatiotemporally, but that are not parts of them. They differ, however, from other cases in which some material objects may be thought to be contained within others without being parts of them. Suppose, for instance, that someone swallows a rock. This would not be a violation of Proper-Contraction $\Rightarrow$ Proper-Parthood. For while the rock is not part of the body, it is not a contraction of it either—the region at which the rock is located is *not* a subregion of the region at which the body is located. Of course, there may be a region with the same “outer” boundary as the body’s location, which has the rock’s location as a subregion. But the body is not located at any such region. If you were to draw the body’s location, you couldn’t just draw a continuous region within a certain perimeter; you would have to take into account cracks and holes of the body, so to speak, and not count the relevant regions as subregions of the body’s location. In doing so, you would not include the rock’s location as a subregion of the body’s location. By contrast, cases violating Proper-Contraction $\Rightarrow$ Proper-Parthood require that a material thing that is not part of another *be* located at a proper

subregion of the region at which the other material thing is located.

Another case: suppose that someone gets shot and the bullet remains stuck in the victim's body. This would not violate Proper-Contraction $\Rightarrow$ Proper-Parthood either. As in the case of the rock, the bullet is not a contraction of the body—the bullet displaces, so to speak, the victim's body, just as a nail displaces the wall it is hammered into. So the bullet's location is not a subregion of the body's location either. By contrast, there is no displacement in violations of Proper-Contraction $\Rightarrow$ Proper-Parthood—a material object is located *within* another material object's location.

Put another way: in violations of Proper-Contraction $\Rightarrow$ Proper-Parthood, we have a pair of material objects that are spatiotemporally related to one another in the same way that someone's arm and her body are spatiotemporally related to one another, but that are not mereologically related to one another in the way that her arm and her body are mereologically related to one another. Neither the rock nor the bullet in the examples above are spatiotemporally related to the victim's body in the way that her arm is spatiotemporally related to her body. Unlike her arm, they are not located at subregions of her body's location.

It's worth distinguishing these kinds of cases from yet others discussed in the literature, such as ones in which there is some *stuff* within a material object's location, or in which a material thing's location is a subregion of another's but the things are made out of different kinds of matter, which interpenetrate one another. In situations violating Proper-Contraction $\Rightarrow$ Proper-Parthood, there's nothing fancy like stuff or interpenetrating kinds of matter. All we have, plain and simple, is a material thing that is not part of another, even though it is located at a proper subregion of its location.

So although one may still find cases violating Proper-Contraction $\Rightarrow$ Proper-Parthood far less disturbing than ones violating Parthood $\Rightarrow$ Contraction, it's clear that they are also quite puzzling. If you understand what's going on in them, you will see that they are rather *sui generis*.

It is, then, these very counterintuitive sorts of violations of both directions of both Parthood $\Leftrightarrow$ Contraction and Composition $\Leftrightarrow$ Expansion that I will be concentrating on in what follows. As I mentioned at the outset, I will argue that their

metaphysical possibility follows from otherwise plausible assumptions about mereological and location relations, together with an otherwise plausible recombination principle for possibility. Provided we may recombine relations of a certain sort in a sufficiently liberal way, and provided parthood and location are relations of that sort, it will follow that the mereological structures of the material world and spacetime—or, equivalently, the mereological and spatiotemporal structures of the material world—may misalign in very radical ways. Let's then move on to discuss the recombination principle that will be at issue.

### 3. RECOMBINATION AND POSSIBILITY

Recombination principles are a family of claims giving sufficient combinatorial conditions for metaphysical possibility—they hold that for such-and-such ways of rearranging such-and-such entities there exists a metaphysically possible world where those entities are arranged in those ways. These principles are sometimes thought of in connection with combinatorial theories of possibility, such as Armstrong's (1989, 1997). Such theories aim to *reduce* modality to recombination—they attempt to ground all possibilities in ways of mixing and matching elements of other possibilities, such that ultimately all possibilities trace back to rearrangements of components of only the actual world. Recombination principles are a key element of any reductive theory along these lines—that's how you get possibilities combinatorially. So the success of any such theory depends on finding the right set of principles, *i.e.* those that are collectively strong enough to deliver all possibilities there are but weak enough not to require impossibilities. However, it is important to notice that recombination principles may hold even if modality is not reducible to recombination, and so even if any such theory fails. Modality will be irreducible to recombination if there are possibilities for which there aren't corresponding rearrangements, *i.e.* possibilities that cannot be generated by mixing and matching elements of other possibilities. What this would mean is that there can be no right set of principles, *i.e.* that any collection of principles that is weak enough not to require impossibilities will fail to deliver all possibilities there are. But it wouldn't mean that recombination

principles are thereby undermined, for such principles offer only sufficient combinatorial conditions for possibility—even if not all possibilities reduce to ways of rearranging elements of other possibilities, it may still be true that for such-and-such rearrangements of such-and-such entities there exists a corresponding possibility. Moreover, recombination principles may be motivated independently of issues concerning modal reduction. As we will see in §5, there are direct arguments for them that are independent of their playing some role in reducing modality. Recombination principles are thus to a great extent independent of the issue of whether modality is reducible to recombination.<sup>12</sup>

Different recombination principles differ on the kinds of entities they apply to—particulars, properties and relations, states of affairs, events, etc.—and on the sorts of rearrangements of those entities they focus on. Recombination principles of the sort that will be relevant here are concerned with properties and relations, and with ways of distributing them over arbitrary particulars. Principles of this sort are often expressed along the following lines:

- (9) Any such-and-such pattern of instantiation of any such-and-such properties or relations is metaphysically possible.

A pattern of instantiation of a single property or relation is just a way in which that property or relation may be distributed over some particulars. For instance, being red may be instantiated in such a way that there are exactly three red things, or in such a way that there are at least seven red things and two non-red ones, or in such a way that everything is red, or in such a way that for every red thing there are at least two non-red ones, etc. Similarly, a pattern of instantiation of a plurality of properties or relations is just a way in which those properties or relations may be distributed over some particulars. For instance, being red and being exactly two feet away from may be instantiated in such a way that there is at least one red thing and everything is exactly two feet away from everything else, or in such a way that every red thing is exactly two feet away from a non-red thing, or in such a way that some non-red things do not

<sup>12</sup> For more discussion on recombination principles and issues in the neighborhood of them, see Saucedo (2009): ch 2.

stand exactly two feet away from each other, etc. So recombination principles along the lines of (9) just claim that any such-and-such ways of distributing any such-and-such properties or relations over some particulars obtains at some metaphysically possible world.

Different recombination principles along the lines of (9) set different restrictions on what kinds of properties and relations are to be recombined, and on what sorts of patterns of instantiation they are to be recombined in. Clearly, the more liberal a principle is, the stronger it is; that is, the more properties and relations a principle applies to, and the more patterns of instantiation of them it encompasses, the more possibilities it will deliver. The argument for the possibility of the cases of external disparities I am interested in requires only a relatively weak principle, which focuses on relations of a certain kind and on distributions of a certain sort. Articulating such a principle is not a trivial task, however; recombination principles are notoriously resistant to systematization. On the one hand, it is hard to give precise formulations of them without making them either too strong or too weak to be of any serious philosophical interest, *i.e.* without identifying them with claims that entail either that uncontroversially impossible situations are possible, or that only uncontroversially possible situations are possible. And without a precise formulation, it is difficult to make anything out of them, for it is unclear exactly what follows from them and what doesn't. On the other hand, restrictions on recombination must not only be precise and neither too lax nor too stringent for recombination principles to come out either absurd or trivial; restrictions must also be *principled*. That is, restrictions on recombination must obey non-ad hoc ways of singling out those entities and those rearrangements of the relevant entities that a given principle applies to. In the case of principles along the lines of (9), this is to say that restrictions on recombination must apply generally to all properties and relations satisfying a certain well-motivated condition, and to all patterns of instantiation of them meeting an also well-motivated condition. Otherwise, it would be arbitrary to rule in or out this or that property or relation among those to be recombined, or this or that pattern of instantiation among those in which they are to be recombined.

I believe, however, that this resistance to systematization may be overcome. Below I suggest one way in which recombination

principles for properties and relations along the lines of (9) may be precisely formulated. This will allow us to precisely articulate a principle that (i) obeys perfectly general and well-motivated restrictions, (ii) is strong enough to deliver the possibility of our cases of external disparities, (iii) is weak enough not to require that uncontroversially impossible situations be possible, and (iv) remains neutral on whether other controversial cases involving mereology, location, material things, and spacetime regions are possible. This will be the principle at the core of the argument in §4.

### 3.1. *Possibly true sentences*

Let's begin by noting that we may state that a certain property or relation is instantiated in some way with a sentence of an artificial language that has a predicate for that property or relation, where such sentence claims (extensionally) that such-and-such is the case. For instance, we may state that being red is instantiated in such a way that for every red thing there are at least two non-red ones with a sentence such as ' $\forall x(Rx \rightarrow \exists y\exists z(\neg Ry \ \& \ \neg Rz \ \& \ y \neq z))$ ', where ' $R$ ' expresses (denotes, stands for, etc.) being red. Similarly, we may state that a plurality of properties or relations is instantiated in some way with a sentence of an artificial language that has predicates for those properties or relations, where such sentence claims that such-and-such is the case. For instance, we may state that being red and being exactly two feet away from are instantiated in such a way that every red thing is exactly two feet away from a non-red thing with a sentence such as ' $\forall x(Rx \rightarrow \exists y(\neg Ry \ \& \ Ax y))$ ', where ' $R$ ' and ' $A$ ' express being red and being exactly two feet away from, respectively. This suggests that we may formulate recombination principles along the lines of (9) in an alternative way, as principles claiming that for any sentence that has a certain logical form and that has occurrences of certain predicates, there exists a metaphysically possible world where that sentence is true.

Here's a more concrete picture of how this might go. Suppose that  $L$  is a first-order language with standard logical vocabulary (the truth-functional connectives, first-order variables and quantifiers, and the identity symbol), whose non-logical vocabulary consists of only a stock of predicates. Let's assume that every  $n$ -place predicate of  $L$  expresses exactly one  $n$ -place property or relation, and

that every  $n$ -place property or relation is expressed by exactly one  $n$ -place predicate of  $L$ .<sup>13</sup> Then we may formulate recombination principles for properties and relations as follows:

- (10) Any such-and-such sentence of  $L$  is true at some metaphysically possible world.

Formulating recombination principles along the lines of (10) intuitively mirrors their formulation along the lines of (9), since such-and-such sentences of  $L$  will have occurrences of predicates expressing such-and-such properties or relations and claim that those properties or relations are distributed over some particulars in such-and-such ways.<sup>14</sup> But, as will become evident below, this kind of formulation will allow us to give more precise renderings of such principles, as well as to better distinguish among them. An added benefit of this kind of formulation is that it affords an in-principle nominalist-friendly approach to recombining properties and relations. For even if one thinks that there are no properties or relations, and hence no rearrangements thereof, one may think that any sentences of a certain language with occurrences of such-and-such predicates and such-and-such logical form are possibly true.

Let's then go on to articulate the recombination principle that will be at issue here. It will be useful to introduce it by placing restrictions on stronger principles.

<sup>13</sup> If you think that there are more properties and relations than a language like  $L$  may have predicates for, that's fine—just assume that there is such a one-one correspondence between the predicates of  $L$  and those properties and relations we normally care about. Also, I do not count the identity symbol as one of the predicates of  $L$ ; so when I talk about the predicates of  $L$  in what follows, I mean the *non-logical* predicates of  $L$ . This is just a terminological point, not a deep claim about identity.

<sup>14</sup> Of course, not all patterns of instantiation of some properties or relations may be captured by sentences of a language like  $L$ ; no sentence of  $L$  may express *e.g.* that a relation is well-founded, or that a relation is the ancestral of another, or that there are uncountably many things with some property, etc. So it's fair to point out that no instance of (10) may capture some instances of (9), and hence that (10) is too constraining on what sorts of possibilities we may in principle get by recombining properties and relations. However, the complications associated with formulating principles along the lines of (10) in terms of a more expressive language outweigh its advantages in the present context—the patterns of instantiation that will be at issue here are relatively simple.

3.2. *Recombination unbound*

Consider the following instance of (10):

- (11) Every sentence of  $L$  is true at some metaphysically possible world.

(11) is a completely unbound recombination principle—it effectively claims that any properties or relations whatsoever may be freely recombined in any way whatsoever. So it is a very strong principle, certainly strong enough for our purposes—it entails that the cases of external disparities at issue are possible, since there are sentences of  $L$  with occurrences of the predicates for parthood, location, material thinghood, and regionhood according to which some material things have parts that are not contractions of them, as well as according to which some material things have contractions that are not parts of them. However, (11) is clearly *too* strong, since it entails that many uncontroversially impossible situations are possible. To see just how strong (11) is, notice that it entails that it is possible that something not be self-identical, that something be both red and not red, that something be both round and red without being red, that something be round without being either round or red, that something be made out of water without being made out of  $H_2O$ , that something have both mass of exactly two grams and mass of exactly three grams, that something be both square and round, that something be square without being polygonal, that something that is exactly one foot long be longer than something that is exactly two feet long, etc. Let's then see how (11) may be constrained, to get a general principle that is still strong enough for our purposes but that we don't have independent reason to reject.

3.3. *Consistency and distinctness*

One obvious issue with (11) is that it entails that logically inconsistent situations are possible. Thus, logical consistency suggests itself as a first restriction on recombination. This restriction yields a weaker principle, according to which any logically consistent distribution of any properties or relations is possible, *i.e.* according to which any properties or relations may be freely recombined in any logically consistent way. Put in terms of sentences of  $L$ , this

would be to constrain (11) to those sentences of  $L$  that have a model, where a model is a familiar set-theoretic structure:

- (12) Any sentence of  $L$  that has a model is true at some metaphysically possible world.

(12) avoids many of the unwelcome consequences of (11), *e.g.* that it is possible that something not be self-identical, that something be both red and not red, that something be both red and round without being red, that something be round without being either round or red, that something be made out of water without being made out of  $H_2O$ , etc. For in these cases it is logically inconsistent that the relevant properties and relations be instantiated in the relevant ways—the corresponding sentences of  $L$  do not have a model.<sup>15</sup> (12), however, still has many of the unwelcome consequences of (11) mentioned above, *e.g.* that it is possible that something have both mass of exactly one gram and mass of exactly two grams, that something be both square and round, that something be square without being polygonal, that a thing that is exactly one foot long be longer than a thing that is exactly two feet long, etc. For in these cases it is logically consistent that the properties and relations in question be instantiated in the relevant ways—there are models of corresponding sentences of  $L$ . So (12) is still too strong—it entails that many uncontroversially impossible situations are possible, and weaker principles would suffice to get the possibility of our cases of external disparities.

A salient feature of these other consequences of (11) is that they involve properties and relations that stand in some determinate-determinable relation to one another. For instance, having mass of exactly one gram and having mass of exactly two grams are determinates of having mass, just as being square and being round are determinates of being shaped. Similarly for being exactly one foot long and being exactly two feet long. On the other hand, being square is a determinate of being polygonal, just as being polygonal is a determinate of being shaped, etc. This suggests that the

<sup>15</sup> This includes cases of a posteriori identities between properties, such as being made out of water and being made out of  $H_2O$ . A sentence of  $L$  requiring that such properties not be identical does not have a model, since these properties are identical and we have stipulated that  $L$  has no more than one predicate for any given property or relation.

consequences of (11) that the logical consistency constraint doesn't filter may be avoided with a restriction regarding determinates and determinables. Let's say that some properties or relations are *determinably-distinct* iff no two of them stand in some determinate-determinable relation to one another. That is, for any properties or relations  $F_1, \dots, F_n$ :

$F_1, \dots, F_n$  are determinably-distinct  $=_{df}$   $F_i$  is not a determinate of  $F_j$ ,  $F_j$  is not a determinate of  $F_i$ , and there is no property or relation  $G$  such that both  $F_i$  and  $F_j$  are determinates of  $G$  (for any  $i, j \in [1, n]$  with  $i \neq j$ ).<sup>16</sup>

Thus, we may further restrict recombination to determinably-distinct properties and relations. Together with the logical consistency constraint, this yields a weaker recombination principle according to which any logically consistent distribution of any determinably-distinct properties or relations is possible, *i.e.* according to which any determinably-distinct properties or relations may be freely recombined in any logically consistent way. Put in terms of sentences of  $L$ : let's say that a sentence of  $L$  is a *D-sentence* of  $L$  iff either it has occurrences of at most one predicate of  $L$ , or it has occurrences of at least two predicates of  $L$  but those predicates express properties or relations that are determinably-distinct. Then we may formulate the principle in question as follows:

- (13) Any D-sentence of  $L$  that has a model is true at some metaphysically possible world.

### 3.4. *Fundamentality*

(13) is weak enough to avoid requiring that any of the clearly impossible situations mentioned above be possible. However, there

<sup>16</sup> It's worth noting that the notion of determinable-distinctness concerns only first-order properties and relations. So some first-order properties or relations may count as being determinably-distinct even if you happen to believe that they are all determinates of second-order properties such as being a property, being a relation, being a property or a relation, etc. I should also mention that although I will remain to a great extent neutral on what the correct account of determinates and determinables might be, I will assume that accounts in terms of entailment (*e.g.* Searle 1959) are unsatisfactory. Arguably the correct account has to do with *structural* relations among properties and relations.

are other ways in which this principle is still too strong. Many philosophers are sympathetic to a layered picture of reality, on which some components of reality are more fundamental than others, and on which facts about less fundamental entities are grounded in or explained by facts about more fundamental ones. More particularly, many philosophers believe that some properties and relations are more fundamental than others, such that facts about less fundamental ones are grounded in facts about more fundamental ones. For instance, most philosophers think that physical properties and relations are more fundamental than mental ones, and that facts about the latter are grounded in facts about the former. Similarly, most think that properties and relations of subatomic particles are more fundamental than properties and relations of atoms and molecules, whereby facts about the former are explained by facts about the latter. Many who are sympathetic to views of this sort think that the connection between more and less fundamental properties and relations is metaphysically necessary, so that more fundamental ones and relations could not be instantiated thus-and-so without less fundamental ones being instantiated thus-and-such. But since at least in principle more and less fundamental properties and relations need not be determinably distinct, and since it is logically consistent that more fundamental ones and relations be instantiated thus-and-such without the less fundamental ones being instantiated thus-and-so, such necessities would be incompatible with (13).

That the connection between more and less fundamental properties and relations is necessary is not as uncontroversial as that logical inconsistencies are impossible, or as that certain links between determinates and determinables are necessary. So there is not the same amount of pressure to weaken (13) as there was in the case of (11) and (12). Still, it would be preferable to have a yet weaker recombination principle, which remained compatible with thinking that the connection between more and less fundamental properties and relations is necessary, and hence which fewer may have independent reason to reject. We may get such a principle by adding a third restriction on recombination, so that it is constrained to *fundamental* properties and relations, *i.e.* properties and relations at the very bottom of the fundamentality ordering, facts about which

are not grounded in facts about other properties and relations.<sup>17</sup> Adding this restriction to the previous two, we get a recombination principle according to which any logically consistent distribution of any determinably-distinct fundamental properties or relations is possible, *i.e.* according to which any determinably-distinct fundamental properties or relations may be freely recombined in any logically consistent way. We may formulate this principle in terms of sentences of *L* as follows. Let's say that a sentence of *L* is an *F-sentence* of *L* iff it has occurrences of predicates expressing only fundamental properties or relations. Then the principle may be formulated thus:

- (14) Any *F-sentence* of *L* that is also a *D-sentence* of *L* and that has a model is true at some metaphysically possible world.

Notice that, without further assumptions, the fundamentality constraint does not make the determinable-distinctness one redundant. For even if one thinks that only maximally determinate properties and relations are fundamental, determinable-distinctness is required to rule out *e.g.* something's having both mass of exactly one gram and mass of exactly two grams.

(14) is a much tamer recombination principle than (11)–(13). It is also strong enough for our purposes—together with the assumptions that parthood, location, material thinghood, and regionhood are fundamental and determinably-distinct, it entails that cases of external disparities are possible. For there are models of sentences of *L* with the predicates for parthood, location, material thinghood, and regionhood according to which these are instantiated so that there are external disparities, *i.e.* it is logically consistent that these be instantiated in the relevant ways.

However, (14) and those assumptions also require that other situations involving parthood, location, material things, and spacetime

<sup>17</sup> Different accounts of fundamentality have been proposed in the recent literature (*e.g.* Fine 1994, 2001; Sider 2009, MS.; Schaffer 2009a, MS.). Of course, the present constraint on recombination is to be understood in whatever the right way of thinking about fundamentality might be. Also, if you happen to think that some properties and relations are more fundamental than others, but that there are no fundamental ones, that's fine—just think of the present restriction as saying that recombination is restricted to properties and relations that are not on the same infinitely descending chain of dependence.

regions be possible. For instance, they entail that it is possible that parthood fail to be transitive for both material objects and regions, that gunky material objects and regions are possible, that any view on when some material things or regions compose another is contingent, that co-located material objects are possible, that it is possible that there be any finite number of material objects or regions, that it is possible that a material object be located nowhere, that all sorts of internal disparities are possible, and so on. For all of these and many other similar situations, there are logically consistent sentences of  $L$  with the predicates for parthood, location, material thinghood, and regionhood according to which these are distributed in the relevant ways.

But, once again, the case for the possibility of external disparities would be much stronger if it didn't also require other possibilities one may have independent reason to reject. So it would be preferable if the case for their possibility didn't generalize for the possibility of any of the other situations above, *i.e.* if it remained neutral as to whether parthood may fail to be transitive, as to whether co-located material things are possible, and so on. As we will see in §4, such a stronger case can be made—there is a more fine-grained but still perfectly general combinatorial path to the possibility of external disparities. A two-prong strategy is required here: we need a still more discerning recombination principle, and we also need to modify the above assumptions about parthood, location, material thinghood, and regionhood. The resulting argument will not only rely on collectively weaker premises that deliver the possibility of external disparities without any of the other controversial possibilities above, but also rest on more plausible assumptions in that it will not require assuming that material thinghood, regionhood, parthood, and location are all fundamental and determinably-distinct. In the remainder of §3, I will explain how to further restrict recombination in the relevant way. In §4, I will introduce the new set of auxiliary assumptions, present the argument, and explain why it doesn't generalize.

### 3.5. *Collective vs. individual distributions, properties vs. relations*

Notice that all the principles above fail to discriminate between two very different kinds of patterns of instantiation: *collective* ones and

*individual* ones, *i.e.* ones in which two or more properties or relations are distributed *together* and ones in which a single property or relation is distributed *on its own*. Independently of what restrictions each such principle may already be constrained by, they all require that collective distributions of properties and relations be possible to exactly the same extent that they require that individual distributions of them be possible. So they require not only that every pattern of instantiation of any two or more such-and-such properties or relations together be possible, but also that every pattern of instantiation of each of them on its own be possible. These are two very different kinds of requirements, however, which may hold independently of one another. In particular, one may think that any collective distribution of any two or more such-and-such properties and relations is possible without thinking that every individual distribution of them is possible. One may in fact think that any distribution of any two or more such properties or relations together is possible while remaining completely neutral as to what impossible distributions there may be concerning each of them on its own. With respect to (14), for instance, one may remain neutral when it comes to the question of whether there are logically consistent but impossible distributions of each fundamental property or relation on its own, but still think that if two or more fundamental properties or relations are determinably-distinct then it is possible that they be distributed together in any logically consistent way. One may *e.g.* be agnostic on whether some actually irreflexive fundamental relation  $R_1$  may fail to be irreflexive, as well as on whether some actually reflexive fundamental relation  $R_2$  may fail to be reflexive, but think that if  $R_1$  and  $R_2$  are determinably-distinct then  $R_1$  and  $R_2$  may be recombined together in any logically consistent way. Of course, any collective distribution of some properties or relations requires that each of them be individually instantiated in some way; that  $R_1$  and  $R_2$  are instantiated together in such a way that something bears  $R_1$  but not  $R_2$  to itself requires that something bear  $R_1$  to itself and hence that  $R_1$  not be irreflexive, as well as that something not bear  $R_2$  to itself and hence that  $R_2$  not be reflexive. So a more careful way to put the point would be as follows: one may be agnostic on whether  $R_1$  may fail to be irreflexive, as well as on whether  $R_2$  may fail to be reflexive, but think that if  $R_1$  and  $R_2$  are determinably-distinct then  $R_1$  and  $R_2$

may be recombined together in any logically consistent way that does not conflict with those ways in which it is necessary that each of them be instantiated on its own, whatever those ways may be. Generalizing: one may remain completely neutral as to what logically consistent but impossible distributions there may be concerning a fundamental property or relation on its own, but think that if two or more fundamental properties or relations are determinably-distinct, then it is possible that they be distributed together in any logically consistent way that does not conflict with those patterns in which it is necessary that each of them be instantiated on its own, whatever such patterns may be.

Notice that such principles also fail to distinguish between two further sorts of patterns of instantiation: ones concerning *properties* and ones concerning *relations*. Independently of what sorts of properties and relations they may already be restricted to, all such principles require that distributions of properties be possible to exactly the same extent that they require that distributions of relations be possible. So (14), for instance, requires not only that every logically consistent pattern of instantiation of any determinably-distinct fundamental relations be possible, but also that every logically consistent pattern of instantiation of any determinably-distinct fundamental properties be possible. But these are again two very different kinds of requirements, which may hold independently of one another. One may think that every distribution of any such-and-such relations is possible without thinking that every distribution of any such-and-such properties is possible. One may in fact remain completely neutral as to what impossible distributions of such properties there may be, but think that any distribution of any such relations is possible; after all, some relations may be distributed over some particulars no matter what clusters of properties those particulars may have, no matter how many particulars with one of those properties there may be, etc. In the example of (14), this would be to think that it is possible that any determinably-distinct fundamental relations be instantiated in any logically consistent way, while remaining completely neutral as to what impossible distributions there may be concerning determinably-distinct fundamental properties, *e.g.* as to whether it is necessary that some such properties cluster together, or necessary that there be a certain number of things with some such property, etc. Of course, some distributions

of such relations are incompatible with certain distributions of such properties. For instance, that some fundamental two-place relation  $R$  is instantiated in such a way that nothing bears  $R$  to itself, everything bears  $R$  to something, and something bears  $R$  to something requires that there be infinitely many things; but this is incompatible with some fundamental property  $F$  being distributed in such a way that everything is  $F$  and there are only finitely many  $F$ s. So a more careful way to put the point would be as follows: one may remain completely neutral as to what impossible distributions there may be concerning determinably-distinct fundamental properties, but think that it is possible that any determinably-distinct fundamental relations be instantiated in any logically consistent way that does not conflict with those ways in which it is necessary that such properties be instantiated, whatever such ways may be.

The idea, then, is that one may place two further restrictions on recombination along the above lines. First, a restriction so that recombination applies to collective distributions and remains completely neutral about individual ones. Second, a restriction so that recombination applies to relations and remains completely neutral about properties. Putting these two restrictions together and adding them to the previous three, we get a recombination principle that applies to logically consistent collective distributions of determinably-distinct fundamental relations, but that remains completely neutral about individual distributions of such relations, as well as about both collective and individual distributions of determinably-distinct fundamental properties. This is a principle according to which for any two or more determinably-distinct fundamental relations, it is possible that they be distributed together in any logically consistent way that does not conflict with those ways in which it is necessary that each such relation be distributed on its own, or with those ways in which it is necessary that determinably-distinct fundamental properties be instantiated either together or on their own, whatever all such ways may be. This is roughly the principle we are looking for, which will deliver the possibility of the cases of external disparities at issue while remaining neutral about the other controversial possibilities above.

Formulating such a principle as an instance of (10) is less straightforward than in the cases of (11)–(14). It would not do, for instance, to simply restrict (14) to those sentences of  $L$  that (i) have a

model, (ii) have occurrences of at least two relational predicates of  $L$  expressing determinably-distinct fundamental relations, but (iii) have no occurrences of predicates of  $L$  expressing anything other than determinably-distinct fundamental relations. For that formulation would not capture the two restrictions just discussed—it would not remain neutral as to whether there are logically consistent but impossible distributions of a single fundamental relation on its own, nor as to whether there are logically consistent but impossible collective or individual distributions of fundamental properties. For instance, consider a sentence of  $L$  that only has occurrences of the predicates for two determinably-distinct fundamental binary relations  $R_1$  and  $R_2$ , and that claims that something bears  $R_1$  to something but not to itself, that everything bears  $R_2$  to something, and that nothing bears  $R_2$  to itself. Since this sentence has a model, the formulation in question would require that it be possibly true. But then it would not remain neutral as to whether  $R_1$  and  $R_2$  are necessarily reflexive, or as to whether  $R_1$  is necessarily non-serial, or as to whether there is a fundamental property  $F$  such that it is necessary that everything be  $F$  but there be only finitely many  $F$ s, etc. The principle in question thus calls for a more subtle formulation.

Here's the basic idea behind the correct formulation. Consider any necessities there may be involving *at most one* fundamental relation. Each such necessity may involve any number of properties or relations of any sort whatsoever (fundamental or not, determinably-distinct or not, etc.) and may concern any distribution whatsoever of such properties or relations (of them together or of each on their own, etc.), so long as it involves either no fundamental relations at all or only one of them. Now take any pattern of instantiation of any properties or relations that involves *at least two* fundamental relations, such that all the fundamental relations it involves are determinably-distinct. Any such pattern may involve any number of properties or relations of any sort whatsoever (fundamental or not, determinably-distinct or not, etc.) and may concern any distribution whatsoever of such properties or relations (of them together or of each on their own, etc.), so long as it involves two or more fundamental relations and all the fundamental relations it involves are determinably-distinct. Then we may think of the principle as claiming that any such pattern is

possible provided it is compatible with those necessities, whatever those necessities may be. So the thought is to isolate any necessities there may be involving at most one fundamental relation, and to think of the principle as claiming that any distribution involving two or more determinably-distinct fundamental relations that does not conflict with those necessities is possible, whatever those necessities may be. Since such necessities will include any way in which it may be necessary that each fundamental relation be instantiated on its own, as well as any way in which it may be necessary that any fundamental properties be instantiated either together or on their own, the principle will remain neutral in all the desired ways.

Let's cash this out in terms of sentences of  $L$ . Consider the set of all sentences of  $L$  that have occurrences of at most one predicate of  $L$  expressing a fundamental relation. Any member of this set may thus have any number of occurrences of any number of predicates of  $L$  of any sort whatsoever (monadic or relational; expressing fundamental properties or relations or not; expressing determinably-distinct properties or relations or not; etc.) and have any logical form whatsoever, so long as it has occurrences of no more than one predicate of  $L$  expressing a fundamental relation. Next, consider the set of all members of such a set that are necessarily true, whatever such sentences may be; call this new set the set of *constraining sentences* of  $L$ .<sup>18</sup> Now, let's say that a sentence of  $L$  is a *candidate sentence* of  $L$  iff it has occurrences of two or more predicates of  $L$  expressing fundamental relations, and the fundamental relations expressed by all such predicates are determinably-distinct. In other words, let a candidate sentence of  $L$  be a sentence of  $L$  that has occurrences of two or more predicates of  $L$  expressing fundamental relations, but that has no occurrences of predicates of  $L$  expressing fundamental relations that are not determinably-distinct. A candidate sentence of  $L$  may thus have any number of occurrences of any number of predicates of  $L$  of any sort whatsoever (monadic or relational; expressing fundamental properties or relations or not; expressing determinably-distinct or not; etc.) and have any logical form whatsoever, so long as it has occurrences of at least two predicates of  $L$  expressing fundamental relations and the fundamental

<sup>18</sup> It's worth making explicit that, by its construction, this set is both logically consistent and closed under logical consequence—I take it that no logical inconsistencies are necessary, and that any logical consequence of a necessity is itself necessary.

relations expressed by all such predicates are determinably-distinct. Then we may formulate our principle as follows: any candidate sentence of  $L$  that is logically consistent with the set of constraining sentences of  $L$ —whatever such sentences may be—is true at some possible world. Letting  $T$  be the set of constraining sentences of  $L$ , this is to say:

( $R \Rightarrow P$ ) For any candidate sentence,  $\phi$ , of  $L$ , such that  $\{\phi\} \cup T$  has a model, there is a metaphysically possible world where  $\phi$  is true.

To get a better grasp on  $R \Rightarrow P$  and to see just how much weaker it is than (14), suppose again that  $R_1$  and  $R_2$  are two determinably-distinct fundamental binary relations. Clearly, (14) alone entails that it is possible that something bear  $R_1$  but not  $R_2$  to itself. By contrast,  $R \Rightarrow P$  alone does not entail this. For  $R \Rightarrow P$  is itself neutral as to what constraining necessities there may be, *i.e.* as to what the contents of  $T$  might be. In particular, it is neutral as to whether  $T$  has members according to which  $R_1$  is irreflexive and according to which  $R_2$  is reflexive. Thus,  $R \Rightarrow P$  entails that it is possible that something bear  $R_1$  but not  $R_2$  to itself only together with further assumptions about the contents of  $T$ , *i.e.* that  $T$  has no members according to which  $R_1$  is irreflexive or according to which  $R_2$  is reflexive. In other words,  $R \Rightarrow P$  delivers such a possibility only in conjunction with further assumptions about what constraining necessities there are, *i.e.* that it is not necessary that nothing bear  $R_1$  to itself and that it is not necessary that everything bear  $R_2$  to itself. Making these further assumptions amounts to assuming that it is possible that something bear  $R_1$  to itself, and that it is possible that something not bear  $R_2$  to itself. So this means that, unlike (14) and its stronger cousins,  $R \Rightarrow P$  delivers non-trivial possibilities only given other non-trivial possibilities: *if* it is possible that something bear  $R_1$  to itself, *and* it is possible that something not bear  $R_2$  to itself, *then*  $R \Rightarrow P$  entails that it is possible that something bear  $R_1$  but not  $R_2$  to itself. On its own, however,  $R \Rightarrow P$  is completely innocuous—alone, it delivers only trivial possibilities, *i.e.* possibilities corresponding to sentences of  $L$  that are true in all models, such as that it is possible that something bear  $R_1$  to itself only if something bears  $R_1$  to something.<sup>19</sup>

<sup>19</sup> Of course, many actually true sentences of  $L$  are not model-theoretic validities, and any such sentence must be compatible with whatever the contents of  $T$  may be. So  $R \Rightarrow P$  does entail some non-trivial possibilities, *i.e.* those that are actual. So a more

A few more points about  $R \Rightarrow P$  are worth noting. First, an explicit constraint for logical consistency is of course no longer required, as it was with (12)–(14). For, clearly, in being constrained to those candidate sentences of  $L$  that are logically consistent with the contents of  $T$ ,  $R \Rightarrow P$  is guaranteed to deliver only logically consistent possibilities.

Second, from the above it should be clear that  $R \Rightarrow P$  may in principle apply to patterns of instantiation involving more than just determinably-distinct fundamental relations. For candidate sentences of  $L$  need not have predicates for only such relations.  $R \Rightarrow P$  may in principle deliver possibilities in which, for instance, fundamental properties are instantiated alongside determinably-distinct fundamental relations. But  $R \Rightarrow P$  is guaranteed not to deliver any problematic possibilities as far as such properties are concerned, since  $T$  will contain whatever necessities there may be involving them. The same is true of non-fundamental properties or relations, as well as of non-determinably-distinct properties or relations—candidate sentences of  $L$  may have predicates for any such properties or relations in addition to predicates for determinably-distinct fundamental relations. So  $R \Rightarrow P$  may in principle also deliver possibilities in which non-fundamental and non-determinably-distinct properties and relations are instantiated alongside fundamental determinably-distinct fundamental relations. But  $R \Rightarrow P$  is guaranteed not to face any of the difficulties afflicting (12) and (13), since  $T$  will contain any ways in which it may be necessary that any non-determinably-distinct properties or relations be instantiated together, as well as any link that may necessarily hold among any more and less fundamental properties or relations. An example to illustrate this: let  $R_1$  and  $R_2$  again be two determinably-distinct fundamental two-place relations, let  $F_1$  and  $F_2$  two non-fundamental or non-determinably-distinct properties, and consider a sentence of  $L$  according to which there is an  $F_1$  that is not an  $F_2$ , and that bears  $R_1$  to itself without bearing  $R_2$  to itself. By definition, this is a candidate sentence of  $L$ . So  $R \Rightarrow P$  may in principle deliver a possibility where it is true, and hence where  $F_1$  and  $F_2$  are instantiated along with  $R_1$  and  $R_2$ . However,  $R \Rightarrow P$  will deliver such a possibility only

careful way to point the point would be as follows: other than actual contingencies,  $R \Rightarrow P$  alone delivers only trivial possibilities. Which is to say that on its own  $R \Rightarrow P$  delivers only trivial non-actual possibilities.

provided that  $T$  has no members conflicting with it, *e.g.* members according to which every  $F_1$  is an  $F_2$ , or according to which no  $F_1$  bears  $R_1$  to itself, or according to which no  $F_1$  fails to bear  $R_2$  to itself, etc. In this case, then,  $R \Rightarrow P$  will deliver this possibility only given two further possibilities: that it is possible that there be an  $F_1$  that is not an  $F_2$  and that bears  $R_1$  to itself, and that it is possible that there be an  $F_1$  that is not an  $F_2$  and that doesn't bear  $R_2$  to itself.

Third, notice that  $R \Rightarrow P$  is effectively a *Humean* principle for fundamental relations. For it requires that there be no necessary connections of a certain sort among them—given any two or more determinably-distinct such relations,  $R \Rightarrow P$  requires that for any ways in which it is possible that each of them be instantiated on its own, it is possible that they be instantiated together in those ways. Moreover,  $R \Rightarrow P$  is a Humean principle for *only* fundamental relations, since it is neutral on whether there are any necessities concerning any other properties and relations. But from the above it should be clear that  $R \Rightarrow P$  encodes only a weak form of Humeanism about fundamental relations—it rejects only some necessary connections among them, and is neutral on whether there are other necessary connections among them. To illustrate the point, suppose again that  $R_1$  and  $R_2$  are two determinably-distinct fundamental two-place relations. Since it is neutral *e.g.* on whether  $R_1$  is necessarily irreflexive as well as on whether  $R_2$  is necessarily reflexive,  $R \Rightarrow P$  is compatible with it being necessary that  $R_1$  is irreflexive iff  $R_2$  is reflexive. Another example: remember that  $R \Rightarrow P$  is neutral as to what necessary truths may connect  $R_1$  and  $R_2$  to non-fundamental or non-determinably properties and relations. So it is neutral as to whether there are non-fundamental properties or relations,  $F_1$  and  $F_2$ , such that (i) necessarily  $R_1$  is instantiated only if so is  $F_1$ , (ii) necessarily  $F_1$  is instantiated only if so is  $F_2$ , and (iii) necessarily  $F_2$  is instantiated only if so is  $R_2$ . So  $R \Rightarrow P$  is compatible with it being necessary that  $R_1$  is instantiated iff  $R_2$  is instantiated. Thus, although  $R \Rightarrow P$  is a Humean principle for fundamental relations, you need not buy into full-blown Humeanism to hold it. Moreover, as we saw above, there are perfectly general ways to distinguish between this weak form of Humeanism about fundamental relations and much stronger ones, such as the one encoded by (14).

$R \Rightarrow P$  is thus the recombination principle that will be at issue here. As should be clear from the above, it is weak enough not to require

that uncontroversially impossible situations be possible. And, as we will see in the next section, it is strong enough to deliver the possibility of the cases of external disparities at issue, while remaining neutral about the possibility of other controversial cases involving mereology, location, material things, and spacetime regions. At the same time,  $R \Rightarrow P$  is a perfectly general principle—it applies to *any* two or more fundamental relations that are determinably-distinct, and to *any* distribution of them together that is compatible with whatever necessities there may be about other properties and relations. Of course, so far I have only articulated this principle, and distinguished it from stronger ones; I have said nothing about why one might think that it is true. I will discuss a direct argument for  $R \Rightarrow P$  in §5 below, when discussing at what cost one may tollens the argument for the possibility of the cases of external disparities at issue. However, I would like to close this section by anticipating two general objections to the way I have articulated  $R \Rightarrow P$  and distinguished it from stronger principles.

First, one might object that, while I may have managed to give a precise formulation of various recombination principles and to clearly distinguish between them, I have failed to provide *principled* distinctions between them, *i.e.* failed to provide non-arbitrary constraints on recombination. For instance, (12) drives a wedge between logically consistent and logically inconsistent patterns of instantiation. But why think that properties and relations may be freely recombined in patterns of only the former sort? That is, why think that only logically consistent distributions of properties and relations are possible? Similarly, (13) distinguishes between determinably-distinct and non-determinably-distinct properties and relations. But why think that properties and relations of only the former sort may be freely recombined in any logically consistent way? That is, why think that logically consistent distributions of only determinably-distinct properties and relations are possible? And so on for subsequent restrictions on recombination yielding increasingly weaker principles, including  $R \Rightarrow P$ —why think that only determinably-distinct fundamental relations may be freely recombined, and only in collective ways that are compatible with the contents of *T*? It seems that if no satisfactory answer to these questions were given, the restrictions behind these principles would be ad hoc. Or so the objection goes.

But the objection is misguided. For the restrictions at issue are not that *only* such-and-such properties or relations may be freely recombined, or that they may be freely recombined in *only* such-and-such ways. Rather, according to these restrictions *all* such-and-such properties or relations may be freely recombined in *all* such-and-such ways. Put another way: these restrictions provide only *sufficient* combinatorial conditions for metaphysical possibility, not *necessary* ones. So these restrictions are unlike clauses found on income tax forms according to which only those with dependents may claim such-and-such deduction, which are meant to exclude those with no dependents from claiming the deduction; the restrictions are more like clauses according to which anyone with dependents may claim the deduction, which are meant to not exclude those with dependents from claiming the deduction. Hence (12) does not claim that properties or relations may be freely recombined in only logically consistent ways; it simply claims that they may be freely recombined in any such way, and is silent otherwise. Similarly, (13) does not claim that only determinably-distinct properties or relations may be freely recombined, or that they may be recombined in only logically consistent ways; it simply claims that all such properties or relations are recombining in all such ways, and is silent otherwise. And so on for all subsequent principles, including  $R \Rightarrow P$ . Thus, it would be mistaken to think that the restrictions behind these principles are ad hoc on the grounds that they draw distinctions between possible and impossible distributions of properties and relations without providing a satisfactory justification for it. That is, it would be wrong to think that they draw a line between possibility and impossibility somewhere but provide no grounds for drawing the line *here* rather than *there*.

Moreover, remember that the requirement that restrictions on recombination be principled is meant to avoid cherry-picking these but not those relevantly similar properties or relations, or these but not those relevantly similar patterns of instantiation of them, among those to which a given principle applies. The thought was that constraints on recombination must apply generally to all properties or relations satisfying a certain well-motivated condition  $\phi$ , and to all patterns of instantiation of them also satisfying a certain well-motivated condition  $\psi$ . But then this kind of arbitrariness may in principle be avoided independently of the further issue of what

explains the fact that only properties and relations satisfying  $\phi$  are freely recombinable, or that they are freely recombinable only in patterns satisfying  $\psi$ . That is, even if some restriction had it that all and only those properties and relations satisfying  $\phi$  are freely recombinable, or that they are recombinable in all and only those patterns satisfying  $\psi$ , the principle would not thereby be ad hoc in the relevant sense—the distinctions between those properties and relations that satisfy  $\phi$  and those that do not, and between those patterns of instantiation that satisfy  $\psi$  and those that do not, may still be well-motivated and perfectly general. Returning to the tax analogy: even if some clause claims that all and only those with dependents may claim the deduction, the distinction between those with dependents and those without dependents is a perfectly general and well-motivated way of partitioning the class of taxpayers. The question of why all and only those with dependents may claim the deduction goes beyond this.

Second, someone may object that the restrictions on recombination I have introduced are either implicitly or explicitly modal. Perhaps, for instance, there are no non-modal accounts of the notions of consistency, of a property or relation being a determinate of another, of a property or relation being more fundamental than another, etc. And even if there are informative non-modal accounts of such notions, the notion of a constraining sentence of  $L$  at the heart of  $R \Rightarrow P$  is explicitly modal. The thought is, then, that at least some of the restrictions on recombination I discussed are constructed out of modal notions, and hence presuppose an independent grasp of what's possible. And the idea is that this is problematic because recombination principles are precisely meant to give us an independent grasp of what's possible.

If principles of the sort I have discussed were to provide the basis for a combinatorial theory of modality, this would be a serious worry. For then clearly such a theory would fail at reducing modality to recombination. However, nothing requires that principles like the above be at the basis of a reductive theory of modality, or that they form part of any such theory at all. Moreover, as discussed at the beginning of this section, recombination principles in general need not stand or fall together with reductive theories of modality. And, beyond this, it's hard to make much out of the objection. Clearly, for instance, there may be non-circular, informative

connections among modal notions. This is particularly true of recombination principles like the above—it is clear that they give substantive, informative conditions for possibility even if at bottom they claim that if thus-and-such is possible then thus-and-so must be possible as well.

#### 4. RECOMBINING PARTHOOD AND LOCATION

Having articulated the recombination principle that will be at issue here, let's move on to the argument for the possibility of the cases of external disparities at stake. Remember from §3.4 above that in order to get the possibility of external disparities from (14) we had to assume that parthood, location, material thinghood, and regionhood are all fundamental and determinably-distinct. Given that we've traded (14) for  $R \Rightarrow P$ , it will be sufficient to assume this only for parthood and location:

- (Fundamentality) Parthood and location are fundamental.
- (Distinctness) Parthood and location are determinably-distinct.

Now, remember that  $R \Rightarrow P$  delivers possibilities only in conjunction with assumptions about the contents of  $T$ , *i.e.* only taking other possibilities as given. Taking the following for granted will be sufficient for our purposes:

- (P1) It is possible that there be two material things and two regions, such that one of those material things is located at one of those regions, and the other material thing is located at the other region.
- (P2) It is possible that there be two material things, one of which is part of the other, and two regions, one of which is not a subregion of the other.
- (P3) It is possible that there be two material things, one of which is not part of the other, and two regions, one of which is a proper subregion of the other.

This is all the argument needs to go through—the metaphysical possibility of the cases of external disparities at issue follows

directly from  $R \Rightarrow P$ , Fundamentality, Distinctness, and P1–P3. Let's see why.

First, let's see how these claims entail that violations of Parthood  $\Rightarrow$  Contraction, and hence of Composition  $\Rightarrow$  Expansion, are metaphysically possible. Consider a sentence,  $\phi$ , of  $L$  according to which a material thing,  $x$ , is part of a material thing  $y$ , but  $x$  is located at a region that is not a subregion of the region at which  $y$  is located. By Fundamentality and Distinctness,  $\phi$  is a candidate sentence of  $L$ . By P1, no member of  $T$  that involves either location or no fundamental relations at all is inconsistent with  $\phi$ . By P2, no member of  $T$  that involves either parthood or no fundamental relations at all is inconsistent with  $\phi$ . So P1 and P2 together guarantee that  $\phi$  is consistent with whatever the contents of  $T$  may be. Thus, by  $R \Rightarrow P$ , there is a metaphysically possible world where  $\phi$  is true.

Second, let's see how  $R \Rightarrow P$ , Fundamentality, Distinctness, and P1–P3 entail that violations of Contraction  $\Rightarrow$  Parthood, and hence of Expansion  $\Rightarrow$  Composition, are metaphysically possible. Consider a sentence,  $\phi$ , of  $L$  according to which a material thing,  $x$ , is not part of a material thing  $y$ , but  $x$  is located at a region that is a proper subregion of the region at which  $y$  is located. By Fundamentality and Distinctness,  $\phi$  is a candidate sentence of  $L$ . By P1, no member of  $T$  that involves either location or no fundamental relations at all is inconsistent with  $\phi$ . By P3, no member of  $T$  that involves either parthood or no fundamental relations at all is inconsistent with  $\phi$ . So P1 and P3 together guarantee that  $\phi$  is consistent with whatever the contents of  $T$  may be. Hence, by  $R \Rightarrow P$ , there is a metaphysically possible world where  $\phi$  is true.

It's worth emphasizing that this all holds whether or not material thinghood and regionhood are fundamental and determinably-distinct. For, as we saw in §3.5 above,  $R \Rightarrow P$  may in principle apply to patterns of instantiation in which determinably-distinct fundamental relations are distributed along with other properties and relations, while safeguarding whatever may be necessary of such other properties and relations. The possibility of the cases of external disparities at issue thus follows independently of any thoughts one may have on the fundamentality and determinably-distinctness of material thinghood and regionhood.

It's clear, then, that the metaphysical possibility of violations of both directions of both Parthood  $\Leftrightarrow$  Contraction and

Composition $\Leftrightarrow$ Expansion, and hence of the very exotic sorts of material objects they involve, follows from  $R\Rightarrow P$ , Fundamentality, Distinctness, and P1–P3. It's interesting to note that by strengthening P2 and P3 just a tiny bit we may get more specific and much more drastic cases of external disparities than the ones above. For instance, consider:

- (P4) It is possible that there be two material things, one of which is part of the other, and two regions, which do not overlap.
- (P5) It is possible that there be two material things, one of which is part of the other, and two regions, one of which is a proper subregion of the other.
- (P6) It is possible that there be two material things that do not overlap, and two regions, one of which is a proper subregion of the other.

By the same reasoning above,  $R\Rightarrow P$ , Fundamentality, Distinctness, P1, and P4 entail that it is possible that a material thing be part of another, but that their locations be completely disjoint. By the same token, if we replace P4 with P5, they entail that it is possible that a material thing be part of one of its proper contractions, *i.e.* that a material thing be part of another, where the location of the latter object is a proper subregion of the former's location. These are two more specific and rather counterintuitive violations of Parthood $\Rightarrow$ Contraction, and hence of Composition $\Rightarrow$ Expansion. Similarly,  $R\Rightarrow P$ , Fundamentality, Distinctness, P1 and P6 entail that it is possible that a material thing that fails altogether to overlap some material object be a proper contraction of that object. This is a more specific and counterintuitive violation of Contraction $\Rightarrow$ Parthood, and hence of Expansion $\Rightarrow$ Composition.

Now, although  $R\Rightarrow P$ , Fundamentality, Distinctness, and P1–P6 are collectively strong enough to deliver the possibility of all the above cases of external disparities, they are also sufficiently weak to deliver none of the other controversial consequences of (14) and the assumptions that parthood, location, material thinghood, and regionhood are all fundamental and determinably-distinct. That is, the argument doesn't generalize—it remains neutral on whether parthood may fail to be transitive, on whether there

may be gunky material objects or gunky regions, on whether any view on composition for material objects or regions is contingent, on whether there may be co-located material objects, on whether there may be any finite number of material objects and regions, and so on. This should be clear from the fact that (i) without taking other possibilities for granted,  $R \Rightarrow P$ , Fundamentality, and Distinctness deliver only trivial possibilities; (ii) P1 makes very few demands about location, material thinghood, and regionhood, whether taken together or on their own; and (iii) P2–P6 make very few demands about parthood, material thinghood, and regionhood, whether taken together or on their own. For instance, P1–P6 are compatible with parthood being necessarily transitive for both material objects and regions, since they are compatible with  $T$  having members according to which parthood is transitive in both cases. Thus, they are compatible with  $R \Rightarrow P$  being unsatisfied for every sentence of  $L$  according to which parthood is not transitive in one case or the other. By the same token, P1–P6 are compatible with unrestricted composition being necessarily true for both material objects and regions, with material objects and gunky regions being impossible, with co-located material objects being impossible, with it being impossible that there be certain cardinalities of material objects and regions, etc. For P1–P6 are compatible with  $T$  having members corresponding to all such necessities.

From this it follows that all the above cases of external disparities are *themselves* neutral on all the controversial consequences of (14) et al. That is, all such cases are themselves compatible with very strong necessities involving parthood, location, material thinghood, and regionhood. It will be useful to go through a couple of interesting cases where this may not be obvious. First, notice that  $\text{Expansion} \Rightarrow \text{Composition}$  may be violated even if composition among material objects is both necessarily unrestricted and necessarily unique, and even if it is necessary that there be no co-located material objects. For suppose that a material object,  $y$ , is an expansion but not a fusion of some material things, the  $x$ s. Then, although the  $x$ s do not compose  $y$ , the  $x$ s may still compose a material thing,  $z$ ; all that's required is that  $z \neq y$ . Moreover, nothing forbids  $z$  from being the only fusion of the  $x$ s. So composition may be both unrestricted and unique in this situation. And since

nothing requires that  $z$  share its location with  $y$ , there need not be co-located material objects in this situation. Second, notice that Proper-Contraction $\Rightarrow$ Proper-Parthood may be violated even if it is necessary that every material object have proper parts, and even if it is necessary that there be no co-located material objects. For suppose that a material thing,  $x$ , is a proper contraction but not a proper part of a material thing,  $y$ . This is compatible with  $y$  having proper parts, and even with  $y$  being gunky; all that's required is that  $x$  not be one of  $y$ 's parts. So everything may have proper parts in this situation. And since none of  $y$ 's proper parts need be a contraction of  $y$ ,  $x$  need not share its location with any of  $y$ 's parts. So there need not be co-located material objects in this situation.

An important point emerges from the above: although  $R\Rightarrow P$ , Fundamentality, Distinctness, P1–P6 entail that the mereological structures of the material world and spacetime may be radically misaligned, they remain to a great extent neutral as to what those structures look like, and as to how exactly location ties the material world to spacetime. Moreover, they even remain neutral as to whether those structures may be internally misaligned:  $R\Rightarrow P$ , Fundamentality, and Distinctness deliver the possibility of internal disparities only if P1–P6 are replaced with more substantive assumptions about the mereological structures of the material world and spacetime, *e.g.* that simple and gunky material things and regions are possible.

It's worth noting that all the above cases of external disparities are also compatible with very strong claims of a different sort. Consider, for instance, universalism about expansion (the claim that any material things have an expansion), uniqueness about expansion (the claim that no material things have more than one expansion), and the claim that every material object has proper contractions.  $R\Rightarrow P$ , Fundamentality, Distinctness, and appropriate replacements of P1–P6 require that none of such claims be necessary, since these are all claims according to which parthood and location are instantiated together in some way. But it's interesting that there may be worlds with external disparities where such claims hold, for it stresses just how little our cases of external disparities require. For instance, Composition $\Rightarrow$ Expansion may be violated at worlds where expansion is both unrestricted and unique. For suppose that some  $x$ s compose but do not expand into some  $y$ . Then the  $x$ s

may still expand into some  $z \neq y$ , where  $z$  is the only expansion of the  $x$ s. So expansion may be both unrestricted and unique in this situation. (Moreover, there need not be co-located material objects in this situation: by definition,  $y$ 's location would not be  $z$ 's location.) Similarly, Parthood $\Rightarrow$ Contraction may be violated at worlds where every material thing has a proper contraction. For if some  $x$  is a part but not a contraction of some  $y$ ,  $y$  may still have proper contractions, as long as  $x$  is not one of them. So everything may have proper parts in this situation. (Moreover, there need not be co-located material objects: by definition,  $x$ 's location would not be the location of any of  $y$ 's contractions.)

Thus, although our argument for the possibility of our cases of external disparities is perfectly general, it does not generalize for other possibilities one may have independent reason to reject.  $R\Rightarrow P$ , Fundamentality, Distinctness, and P1–P6 are sufficiently strong to deliver rather counterintuitive possibilities, but are remarkably innocuous otherwise.

## 5. THE COST OF TOLLENSING

So far I have argued that the possibility of violations of both directions of both Parthood $\Leftrightarrow$ Contraction and Composition $\Leftrightarrow$ Expansion follows from  $R\Rightarrow P$ , Fundamentality, Distinctness, and P1–P6. But all this means is that we have an incompatible set of claims—clearly, one may take this as a *reductio* on at least one of  $R\Rightarrow P$ , Fundamentality, Distinctness, and P1–P6, rather than as evidence for the possibility of external disparities. Below I will argue that tollensing the argument actually leaves us with a choice of alternatives that are at least as unattractive as accepting that external disparities are indeed possible. I will, however, remain neutral as to whether we ought to accept the possibility of external disparities over one of those alternatives. Here I am interested only in highlighting that tollensing the argument comes at a high cost, and that difficult choices are forced upon us no matter what; a thorough assessment of the relative merits and drawbacks of all the options on the table will have to wait for some other time.

Let's begin with P1–P6. P1 is a very weak claim: all it claims is that it is possible that there be two material things and two regions

at which those things are located. So rejecting this claim would seem to be a rather extreme way of tollensing the argument—one would have to hold that it is impossible that there be at least two regions, or impossible that there be at least two material objects, or impossible that a material object be located at some region, etc. As implausible as each of these options may sound, however, there are views in the literature supporting them. Consider, for instance, existence nihilism, the view that there are no concrete objects (Hawthorne and Cortens 1995). Or consider existence monism, the view that there is exactly one concrete object (Horgan and Potrč 2000). Clearly, if either existence nihilism or existence monism is necessarily true, then P1 must be false. But either of these options is arguably at least as unpalatable as accepting that external disparities are possible. For that would require thinking not only that it is possible that there be no concrete objects, or that it is possible that there be only one concrete object; it would require thinking that it is altogether impossible that there be more than one concrete thing.

Notice that, in order to reject P1, it would not be sufficient to defend the necessity of other seemingly less exotic views. For instance, thinking that the bundle theory of particulars is necessarily true is compatible with holding P1. For the bundle theory does not claim that there are no regions or no material objects—it only claims that each of those things is identical to some cluster of compresent properties. In other words, the bundle theory is a view about the *nature* of particulars, not about their *existence*, and P1 is completely neutral as to what the nature of particulars may be. So P1 is compatible with thinking that the bundle theory of particulars is necessarily true. Similarly, thinking that relationalism about spacetime is necessarily true is compatible with holding P1. Substantivalists and relationalists disagree about the nature of spacetime regions, not about their existence—the latter hold that they ontologically depend on material things, and the former hold that they do not. Put another way: substantivalists and relationalists do not disagree as to whether there are true existentially quantified sentences of *L* with the predicate for regionhood. They simply disagree as to whether the truth of such sentences is grounded in the truth of sentences involving the predicate for material thinghood. But P1 is completely neutral on this issue—it is perfectly compatible

with any views you might have as to whether the existence and features of regions are grounded in the existence and features of material objects and relations among them. By the same token, thinking that supersubstantivalism is necessarily true is not sufficient to reject P1. Supersubstantivalism is the view that every material thing is identical to its location. So it does not deny the existence of material objects—it is a view about the nature of such things, not about their existence. And P1 is of course neutral as to what the nature of material things may be.<sup>20</sup> Thus, in order to reject P1, more extreme nihilist theses than the necessary truth of bundle theory, relationalism, or supersubstantivalism are required, *i.e.* that it is impossible that there be any particulars, or any spacetime regions, or any material things. And, once again, these options are arguably at least as unappealing as accepting that external disparities are possible.<sup>21</sup>

Let me now turn to P2 and P3 (similar remarks apply to P4–P6). These are also very weak claims—they only claim that it is possible that there be two material things that are mereologically related in a certain way, and two regions that are mereologically related in a certain way. As in the case of P1, these are false if views like existence nihilism or existence monism are necessary. But there is another option in this case. Notice that P2 entails that it is possible that a material object have proper parts. Similarly, P3 entails that it is possible that a region have proper subregions. So if mereological nihilism about both material objects and regions is necessarily true,

<sup>20</sup> Supersubstantivalism *does* provide a way of resisting the possibility of external disparities, which I address below. My point here is only that the necessary truth of supersubstantivalism does not require that P1 be false.

<sup>21</sup> It might be suggested that there are less extreme means through which to reject P1—one might think that, although it may be necessary that every material object be *weakly* located somewhere, it is nonetheless impossible that a material object have an *exact* location, or impossible that a material object have *only one* exact location (cf. n. 1 above). On the face of it, this suggestion is at least as unappealing as the other options considered above; but, in any case, it is clearly sufficient to refute P1. However, it is ultimately ineffective because the argument could be run with a much weaker premise than P1, *i.e.* that it's possible that there be two material things and two regions, such that one of the material things is weakly located at one of the regions but not at the other, and the other material thing is weakly located at the other region but not at the first. Together with  $R \Rightarrow P$ , Fundamentality, Distinctness, and P2, this claim entails that it's possible that a thing be part of another, but that it be weakly located at a region at which the other is not. So in order to reject this weakening of P1, the more extreme views discussed above are required.

then P2 and P3 must be false. While these are less extreme views than the ones considered above, they are not far behind—they claim that it is altogether impossible that there be composite material objects and composite spacetime regions. So they would seem to be no less unattractive alternatives to accepting the possibility of external disparities.

Let's now take a look at  $R \Rightarrow P$ , Fundamentality, and Distinctness. I will go through them in turn.

As mentioned in §3 above, recombination principles are often dismissed on two sorts of grounds: that they are imprecise and it is unclear what exactly they entail, or that they clearly entail too much.  $R \Rightarrow P$  cannot be dismissed on either of these grounds. Unlike principles along the lines of (9), it is perfectly precise, and it is absolutely clear what exactly follows from it and what does not. And unlike principles such as (11)–(14), it does not entail too much. In fact, remember that  $R \Rightarrow P$  is very weak—it alone delivers only trivial possibilities. Moreover, as we also saw above, the sort of Humeanism about fundamental relations encoded by  $R \Rightarrow P$  is a very weak one; it is immune to standard objections against stronger forms of Humeanism (see *e.g.* deRosset 2009).

Given how weak  $R \Rightarrow P$  is, it is a very hard claim to reject. It may be rejected on independent grounds only if there is a plurality of determinably-distinct fundamental relations other than parthood and location, such that there are independently plausible possible situations concerning only one of those relations (*i.e.* possibilities playing the role of P1–P6) on the basis of which  $R \Rightarrow P$  delivers an independently plausible impossible situation concerning two or more of those relations (*i.e.* a possibility playing the role of the possibility of external disparities). Only then would one have independent evidence against  $R \Rightarrow P$ .

It is hard to think of such an independently motivated case against  $R \Rightarrow P$ . Moreover, one may give a direct argument for  $R \Rightarrow P$ , which would rule out there being such a case. Here is the gist of the argument: arguably the contents of  $T$  allow that  $R \Rightarrow P$  be true of at least some determinably-distinct fundamental relations and at least some non-trivial non-actual ways of instantiating them together. That is, arguably the contents of  $T$  allow that for at least some such relations and at least some such ways of instantiating them together it be metaphysically possible that those relations be instantiated

together in those ways. But then it would be unacceptably *arbitrary* if  $R \Rightarrow P$  did not hold for *all* such relations and *all* such ways of instantiating them together (provided they remain compatible with  $T$ ). For there is nothing special about only some of those relations, or about only some of those ways of instantiating them together—they are all metaphysically on par. So, on pain of arbitrariness,  $R \Rightarrow P$  must hold across the board: for any two or more fundamental determinably-distinct first-order relations and any non-trivial non-actual ways of instantiating them together that are compatible with  $T$ , it is metaphysically possible that those relations be instantiated together in those ways. Call this argument for  $R \Rightarrow P$  the argument from *metaphysical parity*.

The argument from metaphysical parity is the flip-side of the non-arbitrariness requirement for restrictions on recombination discussed in §3. So in order to resist the argument one must either buy into arbitrariness, or else deny that  $R \Rightarrow P$  is true of at least some determinably-distinct fundamental relations and at least some non-trivial non-actual ways of instantiating them together. The former option is unacceptable—nature doesn't play favorites. But the latter one isn't much more appealing. For if  $R \Rightarrow P$  is not true of at least some such relations and some such ways of instantiating them together, then every way in which any two or more such relations are actually instantiated together must be necessary. That is, every actually true sentence of  $L$  with occurrences of two or more predicates expressing such relations and with occurrences of no other predicates must be necessarily true. And this has obviously undesirable consequences—it entails that many arguably contingent features of the actual world are necessary. For instance, it entails that there could not be fewer concrete objects than those that actually stand in determinably-distinct fundamental relations to one another. For the class of actually true sentences of  $L$  with occurrences of two or more predicates expressing such relations and with occurrences of no other predicates entails that there actually are at least  $n$  concrete things, for some  $n$ . But if such sentences are necessarily true, then it is impossible that there be fewer than  $n$  concrete things. This is problematic not only because that there are at least  $n$  concrete things seems to be contingent, but also because such necessity calls for an explanation. And it is hard to even imagine what *could* explain such necessity. Brute modality threatens.

So not only is it hard to think of independently plausible counterexamples to  $R \Rightarrow P$ , but rejecting it leaves us with a choice of unpalatable options: either metaphysical arbitrariness or that seemingly contingent features of the actual world are not only necessary, but also brutally so.

Let me now turn to Fundamentality. Remember that to say that parthood and location are fundamental is to say that facts about them are not grounded in facts about other properties or relations. So in order to reject that parthood is fundamental one can't merely point out that parthood may be defined in terms of other mereological relations, such as proper parthood, overlap, etc. For that would at best show that parthood is not *theoretically* or *conceptually* primitive, not that it is not *metaphysically* primitive. In other words, what's at stake is whether facts about mereological relations are grounded in facts about other properties or relations. This is independent of which mereological relation, if any, is conceptually prior to the rest, and also independent of whether Fundamentality is formulated in terms of parthood or some other mereological relation. Similarly, in order to deny that location is fundamental it is not enough to note that location may be defined in terms of other location relations. The issue is whether facts about location relations are grounded in facts about other properties or relations.

In order to reject Fundamentality, it would also not be sufficient to think *e.g.* that facts about the location of composite material objects are grounded in facts about the location of their simple parts. For that would be to think that there is a fundamental location relation that holds between simple material things and regions, and a non-fundamental location relation that holds between composite material objects and regions, such that facts about the latter relation are grounded in facts about the former relation. So on such a picture there would still be a fundamental location relation, leaving Fundamentality unthreatened. Moreover, violations of  $\text{Contraction} \Rightarrow \text{Parthood}$  need only involve simple material things and their locations—that  $x$  is a contraction but not a part of  $y$  is compatible with both  $x$  and  $y$  being simple. And notice, too, that contrary to claims otherwise (*e.g.* Brzozowski 2008, Williams 2008), this picture is not even incompatible with the existence of cases violating  $\text{Parthood} \Leftrightarrow \text{Contraction}$  and  $\text{Composition} \Leftrightarrow \text{Expansion}$ . For suppose that a material object,  $x$ , is composed of exactly two

material simples,  $y$  and  $z$ , and that these things are located at regions  $S_x$ ,  $S_y$ , and  $S_z$ , respectively. Thinking that either  $S_y$  or  $S_z$  is not a subregion of  $S_x$  is perfectly compatible with thinking that the fact that  $x$  is located at  $S_x$  is grounded in the facts that  $y$  and  $z$  compose  $x$ , and that  $y$  and  $z$  are located at  $S_y$  and  $S_z$ , respectively.

Now, it's hard to see what kinds of facts could serve as independently plausible candidates to ground facts about either mereological or location relations. But not only is it hard to think of independent evidence against Fundamentality—there is also a general worry about rejecting it. The worry is that doing so would effectively undermine *any* combinatorial argument for the possibility of *any* sort of misalignment between the mereological structure of the material world and that of spacetime. As I mentioned at the outset, combinatorial arguments are the main kind of argument that has been offered for the possibility of cases of internal disparities, such as the possibility of material simples with complex locations. Such arguments require Fundamentality as a premise, for as we have seen there is plenty of independent motivation not to want to freely recombine non-fundamental relations. So if one were to reject Fundamentality and still think that it is possible that there be internal disparities, a new kind of argument for such possibilities would be needed, one which didn't generalize for the possibility of external disparities (otherwise there would be no point in rejecting Fundamentality in order to block the argument for the possibility of external disparities). Moreover, on pain of brute modality, a new kind of *explanation* of the possibility of internal disparities would be required, for one could no longer say that they are possible because fundamental relations are freely recombinable.

Of course, one may think that the mereological structures of the material world and spacetime must perfectly align both internally and externally. If so, one would not find it objectionable that rejecting Fundamentality undermines combinatorial arguments for the possibility of misalignments generally, and the demand for an explanation of some possible misalignment would thereby be empty. However, the threat of brute modality appears here as well—an explanation of the necessity of such perfect general alignment would be called for. And it seems that the only view capable of explaining such necessity is supersubstantivalism. Remember that supersubstantivalism is the view that every material thing is

identical to its exact location. So if supersubstantivalism is necessarily true, then both internal and external disparities are impossible—if every material thing *is* its location, then, trivially, its mereological structure and that of its location are perfectly aligned. And if material things *are* their locations, then mereological relations on them and on their locations are trivially preserved in both directions. Thinking that supersubstantivalism is necessary would then fully and easily explain the necessity at issue (Schaffer 2009b defends supersubstantivalism precisely on these grounds).

Thus, not only is it hard to think of independent evidence against Fundamentality; but rejecting it would also undermine the best explanation we have for why misalignments of any sort are possible, and hence leave us with either brute modality or the necessity of supersubstantivalism. And both these choices are at least as unappealing as accepting the possibility of external disparities.

Let's turn to Distinctness. This appears to be an uncontroversial claim: parthood and location do not seem to be related to one another like being red and being blue are, or like being red and being colored are. After all, parthood links material things to material things, and regions to regions, and location links material things to regions; so they would seem to be completely different sorts of relations. As uncontroversial as this may sound, however, supersubstantivalists effectively reject Distinctness. According to them, for a material thing to be located at some region is for it to be that region; so for a material thing to bear some location relation to a region other than itself is for it to overlap that region to some extent. For instance, my body is a certain region, and so is my nose; so my nose gets to be where my body is by being a proper part of it. So for the supersubstantivalist, location relations between material objects and regions are just mereological relations between regions. It follows that location relations and mereological relations are not determinably-distinct—since location relations *are* mereological relations, any determinable that mereological relations fall under is a determinable that location relations also fall under. This in fact explains why for the supersubstantivalist it is trivial that both internal and external disparities are impossible. Remember that we have stipulated that *L* has only one predicate for any given first-order property or relation. So a supersubstantivalist construal of *L* will not include different predicates for location relations and

mereological relations: sentences of *L* concerning location will be sentences with only mereological vocabulary. But then every sentence of *L* according to which parthood and location are instantiated so that there are internal or external disparities is logically inconsistent. For instance, a sentence of *L* according to which a material thing is a part but not a contraction of another is a sentence of *L* saying that something is part of something else without being part of it.

I have already said that I believe that supersubstantivalism is as unappealing an option as accepting that external disparities are possible. And it is hard to think of any other grounds on which one may reject Distinctness. So we are left again with a choice of unappealing alternatives.

Now I would like to discuss one last way in which one may tollens the argument for the possibility of external disparities, which targets a couple of background assumptions rather than  $R \Rightarrow P$ , Fundamentality, Distinctness, or P1–P6. From the outset I have assumed that there is only one fundamental parthood relation and only one fundamental location relation. Call the views that reject these assumptions *mereological pluralism* and *location pluralism*, respectively. Each of these views affords a way to resist the argument for the possibility of external disparities. For instance, mereological pluralism allows for there to be a fundamental parthood relation that holds exclusively among material things, and another fundamental parthood relation that holds exclusively among regions. But then such relations will arguably fail to be determinably-distinct—they are both part–whole relations after all—and hence they will not be amenable to being freely recombined. Similarly, location pluralism would allow for material objects of different mereological complexities to bear different fundamental location relations to spacetime regions. But if so, such relations will not be determinably-distinct, and hence they will not be amenable to being freely recombined.

Regardless of what one may think about the independent viability of pluralist proposals along these lines, blocking the argument for external disparities this way will face the same general worries that rejecting Fundamentality faces. Adopting any such proposal would undermine any combinatorial argument for the possibility of any sort of misalignment between the part–whole structure of

the material world and the part–whole structure of spacetime, since one wouldn't want to freely recombine fundamental relations that aren't determinably-distinct. And if so, once again we would be faced with choosing between brute modality and supersubstantivalism.

Thus, tollensing the argument for the possibility of external disparities comes at a high cost—it leaves us with a choice of equally unappealing alternatives. These are: that existence nihilism is necessary, that existence monism is necessary, that mereological nihilism about both material objects and regions is necessary, that supersubstantivalism is necessary, that there is metaphysical arbitrariness, and brute modality. As I mentioned above, here I will not adjudicate among the possibility of external disparities and one of these choices. But this result should be of significant interest on its own, given how unpopular these alternatives are in the literature nowadays.

## 6. A FEW CONSEQUENCES

I would like to close the essay by noting that whether our cases of external disparities are possible is not an isolated curiosity—the issue is connected to a number of other debates in metaphysics.

Remember from §2 that contraction, proper contraction, and expansion are spatiotemporal relations among material things. This suggested that we may think of external disparities as cases in which there is a mismatch between the mereological relations among some material things and the spatiotemporal relations among them, *i.e.* as cases in which there is mismatch between the mereological and spatiotemporal structures of the material world. Conceiving of external disparities this way—rather than as misalignments between the mereological structures of the material world and spacetime—will allow us to better appreciate how their possibility is relevant to other issues in metaphysics.

Let's begin by noting that although cases of external disparities require that there be a radical misalignment between the mereological and spatiotemporal structures of the material world, they are compatible with those structures being equally *complex*. As we

saw in §4, either direction of Composition $\leftrightarrow$ Expansion may be violated even if both composition and expansion are unrestricted on material objects, *i.e.* even if any material things have a fusion and any material things have an expansion. A material thing,  $y$ , may be an expansion but not a fusion of some material objects, the  $x$ s, even if any material things—including the  $x$ s, as well as the  $x$ s and  $y$ —have a fusion. Similarly,  $y$  may be a fusion but not an expansion of the  $x$ s even if any things—including the  $x$ s, as well as the  $x$ s and  $y$ —have an expansion. So clearly we may have violations of either direction of Composition $\leftrightarrow$ Expansion, and hence misalignments between the mereological and spatiotemporal structures of the material world, even if both composition and expansion are unrestricted, and hence even if those structures are equally complex. However, some of the most interesting ways in which the possibility of external disparities is connected to other debates in metaphysics involve situations in which the mereological and spatiotemporal structures of the material world *differ* in complexity. In particular, they involve two sorts of cases: (i) cases in which expansion is unrestricted and Expansion $\Rightarrow$ Composition is violated, but nihilism about composition holds; and (ii) cases in which composition is unrestricted and Composition $\Rightarrow$ Expansion is violated, but nihilism about expansion holds. To see this, let's first see what it would be for these two kinds of scenarios to obtain.

On the one hand, a material thing,  $y$ , may be an expansion but not a fusion of some material things, the  $x$ s, even if no two or more material objects—the  $x$ s included—have a fusion. A world where this happens and expansion is unrestricted would have spatiotemporally complex material objects but no mereologically complex ones, *i.e.* it would have material objects with proper contractions but no material objects with proper parts. In other words, it would be a world where material reality is *spatiotemporally complex* but *mereologically simple*. On the other hand, a material thing,  $y$ , may be a fusion but not an expansion of some material objects, the  $x$ s, even if no two or more material objects—the  $x$ s included—have an expansion. A world where this happens and composition is unrestricted would have mereologically complex material objects but no spatiotemporally complex ones, *i.e.* it would have material objects with proper parts but no material objects with proper contractions.

In other words, it would be a world where material reality is *mereologically complex* but *spatiotemporally simple*.<sup>22</sup> Of course, that there are metaphysically possible worlds where expansion is unrestricted, Expansion $\Rightarrow$ Composition is violated, but nihilism about composition holds, or worlds where composition is unrestricted, Composition $\Rightarrow$ Expansion is violated, but nihilism about expansion holds, does not follow from R $\Rightarrow$ P, Fundamentality, Distinctness, and P1–P6 alone. For, as we have seen, the latter claims are neutral on whether claims like unrestricted composition and mereological nihilism about material objects are metaphysically possible. Thus, in order to discuss the connections of the possibility of external disparities to other debates in metaphysics, let's set aside whether worlds of these sorts are metaphysically and not only logically possible.

Let's now look at these two kinds of worlds in a bit more detail. A world of the first kind would be populated by material objects of an interesting sort, which I call *crowded simples*. Crowded simples are mereologically simple but spatiotemporally complex material objects, *i.e.* material objects that have proper contractions but no proper parts. Crowded simples may then be arbitrarily large, since they may have arbitrarily large proper contractions. They may also have arbitrary spatiotemporal complexity, since they may have arbitrarily many proper contractions. Moreover, they may have contractions all the way down, *i.e.* each of their contractions may have proper contractions. Their location may even be scattered. Nonetheless, they would be mereologically simple—they would have no proper parts.

The possibility of crowded simples has not been entertained in the literature before. In fact, it has been widely assumed that material simples may have no proper contractions. Sider, for instance, assumes that extended simples could have no proper contractions (2007: 52). Certain views on simples allow for material *stuff* to be

<sup>22</sup> There are of course other ways in which the mereological and spatiotemporal structures of the material world may have different complexities. For there are three general views about composition among material objects: that it is unrestricted, that it is restricted, and that it is nil. And there are three analogous views about expansion among material objects: that it is unrestricted, that it is restricted, and that it is nil. Each of these views on composition is compatible with each of these views about expansion. So the mereological and spatiotemporal structures of the material world may differ in complexity in any of these ways.

located at proper subregions of a simple's location (e.g. Markosian 1998, 2004). But crowded simples have material *things*, not stuff, within their locations.

Not only has the possibility of this new breed of simples not been entertained in the literature before—it is also of great interest for a number of metaphysical debates. For instance, it makes it clear that the mereological nihilist need not be committed to believing that only tiny, structureless material objects exist, as is commonly thought to be the case. In fact, it suggests that she may believe in a multitude of arbitrarily large material objects with an arbitrarily complex structure. So it suggests that the nihilist can recognize the existence of material objects that could in principle be identified with the medium-sized dry goods of common sense—there need not only be tiny particles arranged such-and-such-wise.

Crowded simples also have a strong bearing on debates about how material things extend and change across space and time. First, crowded simples extend across space and time without having spatial or temporal parts. Pertending objects are those that extend over space by having spatial parts, and perduring objects are those that persist over time by having temporal parts. Thus, crowded simples do not extend over space by pertending, nor do they persist over time by perduring, for they have neither spatial nor temporal parts. Nonetheless, crowded simples allow for as much *plenitude* as friends of arbitrary spatial and temporal parts believe in—for any filled spatial or temporal region at a world populated by crowded simples, there may be a material object located at that region (compare with Hawthorne 2006). Moreover, there may be *exactly one* material object at any such region; so there may be plenitude in a non-pertending and non-perduring world even without coincident material objects.

Second, crowded simples may qualitatively vary across both space and time—they may change from being *F* to being *G* across either space or time by having a spatial or temporal contraction that is *F*, and another that is *G*. And they may do so even if *F* and *G* being properties that things have *simpliciter*. Crowded simples thus suggest that material things with neither spatial nor temporal parts may qualitatively vary across space and time without having properties relative to spatial or temporal regions, as well as without having distributional properties (Parsons 2004). So they afford a

new treatment of the so-called problems of temporary and spatial intrinsics (cf. Lewis 1986 and McDaniel 2003, respectively).

Let's now take a look at worlds of the second kind, where composition is unrestricted, Composition $\Rightarrow$ Expansion is violated, but nihilism about expansion holds. Such a world would be inhabited by material objects of another interesting sort, which I call *compact fusions*. Compact fusions are spatiotemporally simple but mereologically complex material things, *i.e.* material things that have proper parts but no proper contractions. Compact fusions may thus be arbitrarily small; their location may even be a mereologically simple region, *e.g.* a point.<sup>23</sup> Nonetheless, they have proper parts. In fact, their proper parts may be arbitrarily large—they may even be proper contractions of one of their proper parts. Moreover, compact fusions may have arbitrarily many proper parts—they may even be gunky, *i.e.* have parts all the way down (or, rather, all the way *up*, or all the way *around!*).

As bizarre as such tiny monsters might be, the idea that a material thing may have parts that are not contractions of it may deserve a second thought. Sider reminds us, for instance, that 'We give metaphorical expression to deep love by saying: "this person is a part of me". Deep loss: "A part of me has been cut out"' (Sider 2007: 54). Surely sayings like these are only metaphorical, but perhaps they hint at something profound—that parthood is a deep, intimate, and special relation that goes beyond spatiotemporal connectedness. The idea that parthood is a relation that 'meaningfully' ties things to one another irrespective of their location is an intuitively appealing one, and may be worthy of serious consideration. Moreover, it would be much in tune with the possibility of crowded simples, for such things also suggest that parthood goes beyond the spatiotemporal bonds that may hold among material things.

The possibility of compact fusions is in any case connected to a number of other debates in metaphysics. For instance, it goes against various sufficient conditions for mereological simplicity that have been offered in the literature. According to Markosian (1998), a material thing is mereologically simple if it is maximally continuous, and McDaniel (2007a) suggests that a material thing is

<sup>23</sup> Of course, compact fusions may be arbitrarily large as well—they may be located at arbitrarily large regions, as well as at regions with arbitrarily many proper subregions, so long as they have no proper contractions.

mereologically simple if it, and only it, is located at some point.<sup>24</sup> But from the above it is clear that a compact fusion may be maximally continuous and located—all alone—at a point. The possibility of compact fusions also goes against the claim that a material thing must be located where its parts are located, which Parsons (2007) considers an *analytic* truth, and Sider (2007) a *constitutive* claim of the nature of parthood. For clearly a compact fusion may fail to be located at a region where one of its parts is located. And the possibility of compact fusions also shows that mereological universalists need not be committed to believing in arbitrarily large, scattered objects, as is commonly thought. For instance, it shows that from the existence of a fusion of the Eiffel tower and my nose it does not follow that there is an object that is located at both Paris and New York.

Crowded simples and compact fusions perhaps also reveal something more general about metaphysical debates concerning the structure of the material world. When one wonders whether there are material simples, perhaps what is really at issue is whether there are material things with no proper *contractions*, not whether there are material things with no proper *parts*. Similarly, when one wonders whether a material thing may be complex all the way down, perhaps what is at issue is whether it may have proper contractions all the way down, not whether it may have parts all the way down. And when one wonders whether a material thing must be complex in order for it to extend and qualitatively vary across space and time, perhaps what is really at issue is whether it must have spatial and temporal contractions, not spatial and temporal parts. Or when one wonders whether some material things make up a further one, perhaps what is at issue is whether they have an *expansion*, not whether they have a *fusion*. So perhaps metaphysicians have focused on the wrong kinds of questions when they have addressed issues about the simplicity and complexity of the material world—maybe what is really at stake is the spatiotemporal structure of the world, not its mereological structure. If so, then we should ask and address questions that have not been explicitly asked or addressed before, instead of the questions we have been

<sup>24</sup> A maximally continuous object is a material thing that is located at a region every subregion of which is occupied by some object or other, and cannot be divided into two regions such that the closure of one shares no subregion with the other.

focusing on so far. For instance, we should ask what are the necessary and sufficient conditions for some material things to expand into another, not what are the necessary and sufficient conditions for some material things to compose another (compare with van Inwagen 1990). Similarly, we should ask what are the necessary and sufficient conditions for a material thing to have no proper contractions, not what are the necessary and sufficient conditions for a material thing to have no proper parts (compare with Markosian 1998).

One may be tempted to think that these questions about contractions and expansions may be addressed in just the same ways that questions about parts and fusions have been addressed in the literature, *i.e.* that debates over contractions and expansions would simply mirror familiar debates over parts and fusions. But it is easy to dispel this thought. For instance, parthood and contraction have very different formal properties: it is a logical truth that if subregionhood is reflexive and transitive, then contraction is both reflexive and transitive. But the same is not true about parthood. Whether parthood is anti-symmetric is controversial, but not as controversial as whether contraction is anti-symmetric (provided subregionhood is anti-symmetric, anti-symmetry for contraction is just the claim that no two material things share their location). On the other hand, we have seen that  $R \Rightarrow P$ , Fundamentality, Distinctness, and P1–P6 entail that any view on when a material thing has proper contractions is contingently true, and similarly with any view on when some material objects have an expansion. But, as we have also seen,  $R \Rightarrow P$ , Fundamentality, Distinctness, and P1–P6 entail nothing about mereological simplicity or complexity. So it is not trivial that one may deal with questions about contractions and expansions just as questions about parthood and composition have been dealt with.

There are various other ways in which the possibility of external disparities is relevant to further metaphysical debates.<sup>25</sup> Let me close with an application to the debate over coincident material objects. Consider the old puzzle of a statue and the lump of clay it's made of. There is a view according to which the lump and the

<sup>25</sup> See *e.g.* Saucedo (2009: ch. 4 and 5) for connections to issues about temporal parts and the possibility of mereological indeterminacy, respectively.

statue are both composed of some plurality of physical particles, but either certain things that are part of the lump are not part of the statue (*e.g.* some scattered claybits), or certain things that are part of the statue are not part of the lump (*e.g.* the statue's head, arms, etc.) (cf. Doepke 1982, Baker 2000, Lowe 2003). Wasserman (2002) suggests that this sort of view is *incoherent*, *i.e.* that it is incoherent that the statue and the lump share all of their microphysical parts without sharing all of their macrophysical ones. The possibility of external disparities makes it clear otherwise, however, provided we think—as friends of distinct coincident objects do—that uniqueness of composition, expansion, and location are not among the necessary truths that hold of parthood and location. For there may be three pluralities of material things, the *x*s, the *y*s, and the *z*s, such that for two material objects, *a* and *b*, (i) *a* and *b* are both fusions and expansions of the *x*s; (ii) *a* is a fusion and an expansion of the *y*s, and an expansion but not a fusion of the *z*s; and (iii) *b* is a fusion and an expansion of the *z*s, and an expansion but not a fusion of the *y*s. Applied to the statue and the lump: one may think that (i) the statue and the lump are both fusions and expansions of some microphysical particles; (ii) the statue is a fusion as well as an expansion of its head, arms, etc., and an expansion but not a fusion of some claybits; and (iii) the lump is a fusion as well as an expansion of those claybits, and an expansion but not a fusion of the statue's head, arms, etc. And not only does the possibility of external disparities show that this view is coherent, but also that the statue and the lump may differ in their categorical features: they differ in their *parts*. So external disparities also afford new treatment of the grounding problem for coincident objects.

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