

THINGS, PLACES, AND POSSIBILITIES:
AN INQUIRY INTO STRUCTURAL DEVIATIONS

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In this work I am concerned with the following issue in metaphysics: how is the part-whole structure of the material world related to the part-whole structure of spacetime? 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 they may somehow mismatch, what sorts of disparities are possible, and why?

I argue that the metaphysical possibility of certain sorts of deviations—which have not been discussed or even entertained in the literature—follows from minimal and otherwise plausible assumptions about modality and the nature of both part-whole relations and relations of spatiotemporal location. These are possibilities in which a material thing, x , is part of a material object, y , but the region at which x is located is not part of the region at which y is located, and in which the region at which x is located is part of the region at which y is located, but x is not part of y . That these possibilities follow from very weak assumptions makes it very hard to resist them—I argue that radical measures are required to avoid them.

I also discuss a few consequences of accepting these possibilities for other debates in metaphysics. I delve deeply into two such consequences. First, I suggest that these possibilities afford a new way of resisting an influential argument for the existence of temporal parts: the so-called argument from vagueness. Second, I argue that these

possibilities allow us to have indeterminacy in matters of part and whole without indeterminacy in matters about identity, existence, and cardinality. This provides a new way of defending indeterminacy in matters of part and whole against influential objections in the literature.

BIOGRAPHICAL SKETCH

I was born in Mexico City in 1979. I completed a B.A. in philosophy at the National Autonomous University of Mexico (UNAM) in 2003, having spent my junior and senior years as a visiting student in the philosophy department at UC Berkeley. I wrote an undergraduate thesis on Frege's philosophy of language and mathematics, under the supervision of Mario Gómez Torrente. I enrolled in the philosophy PhD program at Cornell University in 2003. I did my dissertation work with Matti Eklund, finishing the present work in 2009. While as a graduate student at Cornell, I visited Berkeley again for a substantive amount of time in 2006-2008. Starting in the fall of 2009, I will spend four years alternating between two research posts: a post-doc in the philosophy department at Yale University, and a fellowship in Jonathan Schaffer's fundamentality project at the Australian National University.

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CHAPTER 1
ALIGNMENTS AND MISALIGNMENTS

1.1 The Issue, in a Nutshell

The material world has a part-whole structure. One may, of course, disagree about what that structure looks like—there are different views as to how exactly material things are arranged into part-whole relations. For instance, one may think that any material things make up a whole, or that only some or even none of them do. Similarly, one may think that there are material things with no parts, or material things with parts all the way down. But regardless of one's views on these specific issues, everyone would agree that the material world has some part-whole structure or other. Part-whole relations organize material things in some way or other.

Spacetime, too, has a part-whole structure. There may also be disagreements about the makeup of that structure. As with material things, there are different views as to how exactly spacetime regions are arranged into part-whole relations. One may think that any regions make up a further region, or that only some or even none of them do; one may think that there are regions with no subregions, or regions with subregions all the way down; etc. But, as with the material world, no one would deny that spacetime has some part-whole structure or other, regardless of any more specific views one might have about that structure. Part-whole relations organize spacetime regions somehow or other.

Now, the material world is located in spacetime. One may again disagree about the nature of that connection: there are different views as to how exactly location

relations tie material things to spacetime regions. For instance, one may think that no spacetime region has more than one exact occupant, or that some of them do. Similarly, one may think that no material object has more than one exact location, or that some of them do. But, once again, even though one may disagree about these specific issues, 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 one way or another.

These basic facts about the material world and spacetime—that both the material world and spacetime have a part-whole structure and that the material world is located in spacetime—give rise to an interesting issue, which has been only partially and indirectly addressed in the literature. The issue is this: given that the material world is located in spacetime, how are their part-whole 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 what explains those possibilities?

This is the issue that I will be primarily concerned with in this work. My main aim is to argue that the metaphysical possibility of certain sorts of deviations—which have remained completely ignored in the literature, and which have a strong bearing on various interesting debates in metaphysics—follows from minimal and otherwise plausible assumptions about metaphysical modality and the nature of both part-whole relations and relations of spatiotemporal location.

1.2 The Issue, in a Bit More Detail

To get a better grip on the issue and on what exactly I will argue here, it will be useful to introduce a few notions and preliminary assumptions concerning three sorts of first-order relations: relations of part and whole, relations of spatiotemporal location, and relations of relative spatiotemporal location.

1.2.1 Relations of Part and Whole

Relations of part and whole concern what is part of what, what overlaps what, what composes what, etc. They are also called *mereological* relations, from *meros*, the Greek word for part. I will preliminarily systematize these relations by taking the parthood relation of classical mereology as undefined and defining other part-whole relations in terms of it in the usual way.¹ That is, I will take parthood to be a topic-neutral, two-place, reflexive, transitive, and anti-symmetric relation that does not hold relative to times, places, worlds, sorts, or anything else, in terms of which we may define proper parthood, overlap, and composition as follows:

(Proper Parthood)

x is a proper part of $y =_{df}$ x is part of y and y is not part of x .

(Overlap)

x overlaps $y =_{df}$ something is part of both x and y .

¹For different systematizations of these relations, including classical mereology and its extensions, see Simons 1987. Even though interest in relations of part and whole has been present throughout the history of philosophy, their systematic treatment did not arrive until Leśniewski 1916, Tarski 1929, and Goodman and Leonard 1940.

(Composition)

the x s compose y (y is a fusion of the x s) =_{df} each of the x s is part of y , and every part of y overlaps at least one of the x s.

A few examples will help clarify these relations. Let H be my head, N my nose, B my body, RB the right half of my body, LB the left half of my body, TB the top half of my body, and BB the bottom half of my body. Similarly, let S_H be the head-shaped region where my head is located, S_N the nose-shaped region where my nose is located, S_B the body-shaped region where my body is located, S_{RB} the right half body-shaped region where the right half of my body is located, S_{LB} the left half body-shaped region where the left half of my body is located, S_{TB} the top half body-shaped region where the top half of my body is located, and S_{BB} the bottom half body-shaped region where the bottom half of my body is located. Then parthood is meant to be a relation that (prima facie) H bears to H , B , and TB , but not to N , RB , LB , or BB . Similarly, it is meant to be a relation that (again, prima facie) S_H bears to S_H , S_B , and S_{TB} , but not to S_N , S_{RB} , S_{LB} , or S_{BB} . Proper parthood is meant to be a relation that H bears to B and TB , but not to H , N , RB , LB , or BB . Similarly, it is meant to be a relation that S_H bears to S_B and S_{TB} , but not to S_H , S_N , S_{RB} , S_{LB} , or S_{BB} . Overlap is meant to be a relation that H bears to H , N , B , RB , LB , TB , but not to BB . Similarly, it is meant to be a relation that S_H bears to S_H , S_N , S_B , S_{RB} , S_{LB} , and S_{TB} , but not to S_{BB} . Finally, composition is meant to be a relation that B bears to B , that RB and LB bear to B , that TB and BB bear to B , and that any three or more of RB , LB , TB , and BB bear to B , but that RB and TB do not bear to B , that H and BB do not bear to B , that not one or more of H , B , RB , LB , TB , and BB bear to N , etc. Similarly, it is meant to be a relation that S_B bears to S_B , that S_{RB} and S_{LB} bear to S_B , that S_{TB} and S_{BB} bear to S_B , and that any three or more of S_{RB} , S_{LB} , S_{TB} , and S_{BB} bear to S_B , but that S_{RB} and S_{TB} do not

bear to S_B , that S_H and S_{BB} do not bear to S_B , that not one or more of S_H , S_B , S_{RB} , S_{LB} , S_{TB} , and S_{BB} bear to S_N , etc.

Given these relations, we may define a few other mereological notions that will be useful in what follows: what it is for something to be mereologically *simple*, what it is for something to be mereologically *complex*, and what it is for something to be mereologically *gunky*. These are as follows:

(Mereological Simplicity)

x is mereologically simple =_{df} x has no proper parts.

(Mereological Complexity)

x is mereologically complex =_{df} x is not mereologically simple.

(Mereological Gunkiness)

x is mereologically gunky =_{df} every part of x has proper parts.

A few examples to illustrate these notions. Prima facie, elementary physical particles would count as mereologically simple, since such things seem to have no proper parts. Similarly, spacetime points would count as mereologically simple, since such things seem to have no proper subregions. On the other hand, my body would count as a mereologically complex material thing, since it has proper parts (*e.g.* my head). Similarly, the body-shaped spacetime region where my body is would count as mereologically complex, since it has proper subregions (*e.g.* the head-shaped region where my head is). Ordinary examples of gunky things are hard to come by. But my nose, for instance, would count as gunky if it had no mereologically simple things as parts. Similarly, the nose-shaped region where my nose is would count as gunky if it had no mereologically simple subregions as parts.

I will assume, then, that part-whole relations understood as above organize both material things and regions of spacetime somehow or other—both the material world and spacetime get their part-whole structures, whatever they may look like, via such part-whole relations. This is to assume that if either material things or spacetime regions stand in some part-whole relation to one another, then such relation must be definable in terms of the parthood relation I am taking as undefined. An important consequence of this assumption is that for a spacetime region to be a subregion of another is just for the first to be part of the second.

I should stress that these are all preliminary assumptions. Two points are worth noting in this respect. First, choosing parthood understood as above as our theoretical primitive is purely for simplificatory purposes. Instead of parthood we could have taken another part-whole relation as undefined, and defined other part-whole relations in terms of it (for instance, it is easy to show that parthood, proper parthood, overlap, and composition are interdefinable taking one of them as undefined). Similarly, we could have taken parthood (or whatever other mereological primitive) to hold relative to something (*e.g.* times and worlds), or to have different properties (*e.g.* that parthood is not transitive). Everything I will say here is compatible with any of that. Second, in §3.3 below I will explicitly discuss how what I will argue here would be affected if we thought that there was more than one sort of mereological relation, *e.g.* if we thought that there was one sort of part-whole relations that held exclusively among material things and another completely different sort of part-whole relations that held exclusively among regions of spacetime. So, even if you find these notions and assumptions about part-whole relations problematic or somehow inadequate, let me hang on to them for the time being.

1.2.2 Relations of Spatiotemporal Location

Relations of spatiotemporal location concern where things are in spacetime. I will systematize these relations by taking as undefined the relation Josh Parsons calls *weak* location, and defining other location relations in terms of it (Parsons 2007). Weak location is an unrelativized two-place relation that some things bear to regions of spacetime, which Parsons informally characterizes thus: “I should count as weakly located in my office when I am sitting at my desk, when I am reaching an arm out the window, or when I am reaching an arm in the window from the street outside” (p. 203). In terms of weak location and part-whole relations among spacetime regions, we may define stronger location relations, such as entire location, pervasive location, and exact location:

(Entire Location)

x is entirely located at $S =_{df}$ x is located at S , and x is located at some region S' only if S and S' have subregions in common.

(Pervasive Location)

x is pervasively located at $S =_{df}$ x is located at some region S' if S and S' have subregions in common.

(Exact Location)

x is exactly located at $S =_{df}$ x is both entirely and pervasively located at S .

To illustrate these relations, consider the following examples (where all abbreviations are as above). Weak location is meant to be a relation that H bears to S_H , S_N , S_B , S_{RB} , S_{LB} , and S_{TB} , but not to S_{BB} . Entire location is meant to be a relation that H bears to

S_H , S_B , and S_{TB} , but not to S_N , S_{RB} , S_{LB} , or S_{BB} . Pervasive location is meant to be a relation that H bears to S_H and S_N , but not to S_B , S_{RB} , S_{LB} , S_{TB} , or S_{BB} . Finally, exact location is meant to be a relation that H bears to S_H , but not to S_N , S_B , S_{RB} , S_{LB} , S_{TB} , or S_{BB} .

For simplicity's sake, when I talk about location in an unqualified manner in what follows, I will mean the location relation I have taken as undefined, *i.e.* weak location. I will also assume that exact location is a total function on material objects, *i.e.* that every material object has exactly one exact location. This will allow us to talk about *the* exact location of a material thing.

I will assume, then, that the material world is connected to spacetime through location relations understood as above—material things are tied to spacetime regions, somehow or other, via such relations. This is to assume that if some material object bears some location relation to a region of spacetime, then such relation must be definable in terms of the location relation I have taken as undefined.²

As with part-whole relations, these are all preliminary assumptions. First, my choice of weak location understood as above as a theoretical primitive is only for simplicity's sake. Everything I will say here is compatible with *e.g.* taking some other location relation as undefined, and defining other location relations in terms of it (weak, entire, pervasive, and exact location are interdefinable taking any of them as primitive). Similarly, everything I will say here is compatible with thinking that location relations must be indexed to something (*e.g.* times and worlds), and that they hold between things and regions of space instead of spacetime. Second, in §3.3 I will

²Of course, these location relations need not hold exclusively among material things and regions of spacetime. If there are any such things as immanent universals, tropes, events, etc., then perhaps these also bear location relations understood as above to spacetime. Here, however, I will only concentrate on material things.

explicitly discuss how what I will argue is affected by thinking *e.g.* that exact location is not a total function on material objects, or by thinking that there is more than one sort of location relations tying material things to spacetime, which are not be interdefinable. Again, hold any reservations you might have about location relations understood as above until later.

On the other hand, it is worth noting two issues regarding location relations that I will be making no assumptions about: the nature of spacetime, and the nature of the material world.

First, accepting the existence of relations of spatiotemporal location construed of as above does not require substantivalism about spacetime. Substantivalism is a view about the nature of spacetime, according to which spacetime regions are ontologically independent of material things. But notice that relationalism about spacetime—the view that spacetime regions ontologically depend on material things—is compatible with some material things being located at some spacetime regions. In other words, relationalists merely claim that spacetime regions exist in virtue of the existence of material things, not that material things have no spatiotemporal location. Relationalism *does* have a bearing on the issue that I will be concerned with here, and I will discuss that in §3.3. The point here is only that admitting the existence of location relations understood as above does not require taking sides on the debate between substantivalism *vs.* relationalism about spacetime.

Second, accepting the existence of spatiotemporal relations understood as above does not require that there be an ontological duality between material things and spacetime regions. Supersubstantivalism is a view about the nature of the material world, according to which material things are identical to the regions of spacetime

at which they are exactly located. So, supersubstantivalism rejects the existence of a duality between material things and regions of spacetime. But then notice that supersubstantivalism is compatible with some material things being located at some spacetime regions—for the supersubstantivalist, this is just to accept that some regions are identical to themselves. In other words, supersubstantivalists merely claim that material things are a certain kind of thing, not that they lack spatiotemporal location. As with relationalism, supersubstantivalism does have a bearing on the issue I will be concerned with here, which I will also discuss in §3.3. But merely accepting the existence of location relations understood as above does not require assuming that supersubstantivalism is false.

1.2.3 Relations of Relative Spatiotemporal Location

Relations of relative spatiotemporal location concern where a thing is located relative to where another thing is located, or where some things are located relative to where other things are located. I will systematize these relations via part-whole relations among spacetime regions where the relata are exactly located:

(Contraction)

x is a contraction of $y =_{df}$ x 's exact location is a subregion of y 's exact location.

(Proper Contraction)

x is a proper contraction of $y =_{df}$ x is a contraction of y and y is not a contraction of x .

(Expansion)

the x s expand into y (y is an expansion of the x s) \equiv_{df} the exact locations of the x s compose the exact location of y .

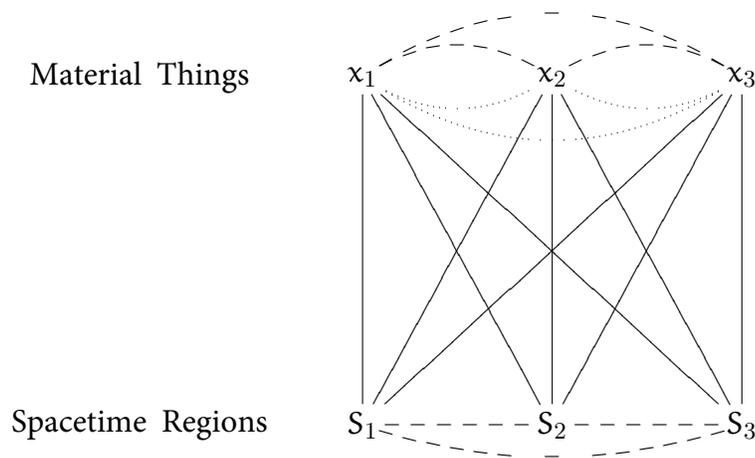
So, to say that x is a contraction of y is to say that the region at which x is exactly located is a subregion of the region at which y is exactly located. To say that x is a proper contraction of y is to say that the region at which x is exactly located is a proper subregion of the region at which y is exactly located. And to say that the x s expand into y (or, what is the same, that y is an expansion of the x s) is to say that each of the x s is exactly located at a subregion of the region at which y is exactly located, and that every region at which y is (weakly) located has subregions in common with the exact location of at least one of the x s.³

As with relations of part and whole and relations of spatiotemporal location, a few examples will help clarify these relations (I again use the same abbreviations as above). Contraction is meant to be a relation that H bears to H , B , and TB , but not to N , RB , LB , or BB . Proper contraction is meant to be a relation that H bears to B and TB , but not to H , N , RB , LB , or BB . And expansion is meant to be a relation that B bears to B , that RB and LB bear to B , that TB and BB bear to B , and that any three or more of RB , LB , TB , and BB bear to B , but that RB and TB do not bear to B , that H and BB do not bear to B , that not one or more of H , B , RB , LB , TB , and BB bear to N , etc.

³Even though there has been plenty of indirect and implicit discussion of these notions in the literature, this is the first attempt at explicitly spelling them out and treating them in a systematic way. The contraction/expansion terminology comes from Sider (2007). However, Sider's usage of 'expansion' differs from mine in two important respects. On the one hand, he thinks that expansion is a relation that single things bear to single things, not that pluralities of things bear to single things. On the other, 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.

It is important to emphasize that relations of relative spatiotemporal location are relations that hold among some things solely on the basis of the mereological relations that happen to hold among those things' exact locations, not in virtue of certain mereological relations holding among those things. So if you were to specify what relations of relative spatiotemporal location some things stand in to one another, it would be necessary and sufficient to specify the mereological relations among their exact locations. This will be important in what follows.

In sum, I have introduced three sorts of first-order relations that shape the material world and spacetime: relations of part and whole, which link material things to material things, as well as spacetime regions to spacetime regions; relations of spatiotemporal location, which link material things to spacetime regions; and relations of relative spatiotemporal location, which link material things to material things, based on how their exact locations are mereologically related. The picture below depicts these three sorts of relations at work in a toy world with three material things, x_1 , x_2 , and x_3 , and three spacetime regions, S_1 , S_2 , and S_3 :



- - -: Relations of part and whole.
- : Relations of spatiotemporal location.
- · ·: Relations of relative spatiotemporal location.

In this picture, mereological relations link $x_1, x_2,$ and x_3 to each other in some way or another. Mereological relations also link $S_1, S_2,$ and S_3 to each other in some way or another. Location relations tie $x_1, x_2,$ and x_3 to $S_1, S_2,$ and S_3 in some way or another. And relations of relative spatiotemporal location link $x_1, x_2,$ and x_3 to each other, on the basis of the location relations that they happen to bear to $S_1, S_2,$ and S_3 and the mereological relations that $S_1, S_2,$ and S_3 happen to bear to one another.

1.2.4 Two Sorts of Misalignments

We are now in a position to better spell out the issue I will be concerned with here, and what I will argue about it. Once again, the issue is 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. If so, what kinds of disparities are possible, and what explains their possibility? Otherwise, what explains the necessary perfect correspondence between those structures?

Here is 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 exactly located. Mereologically simple material things that are exactly located at mereologically complex spacetime regions would be one case where this sort of misalignment occurs. For other cases, consider mereologically complex material objects that are exactly located at mereologically simple regions, gunky material objects that are exactly located at non-gunky regions, and non-gunky material objects that are located at gunky regions. I call disparities of the sort involved in these cases *internal deviations*, since they concern the internal mereological structure of material things and their exact locations.

Put a bit more generally, internal deviations occur when biconditionals such as the following are violated in one or the other direction where all of the following are universally quantified over material things):

(1-1) x is mereologically simple iff x 's exact location is mereologically simple.

(1-2) x is mereologically complex iff x 's exact location is mereologically complex.

(1-3) x has exactly κ parts iff x 's exact location has exactly κ subregions.⁴

(1-4) x is mereologically gunky iff x 's exact location is mereologically gunky.

I call biconditionals of this sort *internal alignment principles*. Characterizing internal deviations generally as disparities where internal alignment principles are violated in one or the other direction makes it clear that they involve cases in which either the

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

part-whole structure of a material thing fails to be preserved onto its exact location, or the part-whole structure of a material thing's exact location fails to be preserved onto that thing.

But there is 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 that of its exact location, but between the mereological relations on some material things and the mereological relations on those things' exact locations. Generally, these are disparities in which biconditionals like the following are violated in one or the other direction:

(1-5) x is part of y iff x 's exact location is a subregion of y 's exact location.

(1-6) x is proper part of y iff x 's exact location is a proper subregion of y 's exact location.

(1-7) x and y overlap iff x 's exact location and y 's exact location overlap.

(1-8) the x s compose y iff the exact location of the x s compose y 's exact location.

In cases violating these principles, either the mereological relations on some material objects fail to be preserved onto those objects' exact locations, or the mereological relations on some material objects' exact locations fail to be preserved onto those objects. I call disparities violating these principles *external deviations*, since they concern external mereological relations among material objects and their exact locations, regardless of what their internal mereological structures may be. Correspondingly, I call biconditionals like the above *external alignment principles*.⁵

⁵These principles were independently articulated by Gabriel Uzquiano (forthcoming), around the same time that I articulated them in Saucedo (forthcoming). Uzquiano calls them principles of mereological *harmony*. I prefer my label to his, given that there are two notions of mereological harmony (*i.e.* internal and external), which, as we will see below, are logically independent of one another.

What is the connection between these two varieties of mereological mismatching? If there are internal deviations, must there be external ones? And if there are external deviations, must there be internal ones? The answer to both of these questions is *no*. Here is why.

First, for a situation with internal but no external deviations, suppose that there is exactly one material thing, and that such thing is a mereological simple that is exactly located at a mereologically complex region. Then the mereological structure of some material thing and that of its exact location fail to perfectly align: the simple has no proper parts, but its exact location has proper subregions. But all the mereological relations on any material things and their exact locations are nonetheless fully preserved in both directions: no external alignment principle is violated. So internal deviations do not require external ones.

Second, for a situation with external but no internal deviations, suppose that there are exactly two material objects, that each of those things is a mereological simple, and that they are co-located at a mereologically simple region. Here the part-whole structure of every material thing perfectly matches that of its exact location: no internal alignment principle is violated. But various mereological relations on some material objects' exact locations fail to be preserved onto those objects. That is, the right-to-left direction of various external alignment principles is violated: the exact locations of the simples are subregions of one another, but neither simple is part of the other; the exact locations of the simples have subregions in common, but the simples have no parts in common; the exact locations of the simples compose the exact location of either simple, but the simples compose neither simple. So external deviations 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. This shows that, at least in principle, one may accept the metaphysical possibility of internal deviations without accepting the metaphysical possibility of external ones, and the other way around.⁶

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 space-time fail to perfectly align breaks down into two more specific issues. The first one is whether internal deviations are metaphysically possible. If so, which forms of internal deviations are possible, and what grounds their possibility? Otherwise, what explains the necessary truth of internal alignment principles? The second issue is whether external deviations are metaphysically possible. If so, which forms of external deviations are possible, and what grounds their possibility? Otherwise, what explains the necessary truth of external alignment principles?

The first issue has received a fair share of attention in the recent literature. It has not been raised 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 mereologically simple material objects be exactly located at regions with proper subregions, *i.e.* whether violations to the left-to-right direction of (1-1) are possible (see *e.g.* Markosian 1998, 2004; Parsons 2000; McDaniel 2007a, 2007b; Sider 2007). The possibility of other forms of internal deviations has also been discussed in the literature, if to a lesser extent (*e.g.* McDaniel 2007a, 2006; Hudson 2007).

⁶Of course, this is compatible with there being connections between *specific* forms of external and internal deviations. Uzquiano (forthcoming), for instance, effectively argues that certain forms of internal deviations require certain forms of external ones.

By contrast, the second issue has received practically no attention in the literature—whether external deviations are metaphysically possible has not been addressed or even entertained. My main aim in this work is to fill this gap: I will be concerned with whether certain cases of external deviations are metaphysically possible. The cases I am interested in are ones in which both directions of both (1-5) and (1-8) are violated, *i.e.* in which both parthood and composition fail to be preserved both from some material things to their exact locations and from some material things' exact locations to those things. I will argue that the metaphysical possibility of these cases follows from minimal and otherwise plausible assumptions about modality and the nature of both part-whole relations and relations of spatiotemporal location. I will suggest, moreover, that these cases are philosophically interesting not only because they require a pretty radical and thus far unforeseen misalignment between the mereological structures of the material world and spacetime, but also because they have a strong bearing on various debates in metaphysics. Let me briefly characterize these cases of external deviations in a way that will help make this more apparent, and sketch the argument that I will give for their possibility.

1.3 Parts vs. Contractions, Fusions vs. Expansions

Remember that a material thing is a contraction of another iff the region at which the first is exactly located is a subregion of the region at which the second is exactly located. Notice, then, that (1-5) 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 the first be a contraction of the second:

(Parts \Leftrightarrow Contractions)

x is part of y iff x is a contraction of y .

Similarly, remember that some material things expand into a material object iff that object is exactly located at a region composed of the regions at which those things are exactly located. So notice that (1-8) is equivalent to the following principle, according to which in order for some material things to expand into another it is both necessary and sufficient that they expand into it:

(Composition \Leftrightarrow Expansion)

the x s compose y iff the x s expand into y .

And notice that (1-8) and Composition \Leftrightarrow Expansion are equivalent to the following principle, according to which for a material thing to be a fusion of some material objects it is necessary and sufficient that it be an expansion of those objects:

(Fusions \Leftrightarrow Expansions)

y is a fusion of the x s iff y is an expansion of the x s.

This shows that there are two equivalent ways of characterizing external deviations: as cases in which there is a mismatch between the part-whole relations among some material things and the part-whole relations among those things' exact locations, and as cases in which there is a mismatch between the part-whole relations among some material things and the relations of relative spatiotemporal location among those things. For instance, to say that parthood fails to be preserved either

from some material things to their exact locations, or from some material things' exact locations to those material things, is just to say that there is a mismatch between parthood and contraction, in one direction or the other. Similarly, to say that composition fails to be preserved either from some material things to their exact locations, or from some material things' exact locations to those material things, is just to say that there is a mismatch between composition and expansion, in one direction or the other. In general, then, to say that the mereological relations on some material things and the mereological relations on those material things' exact locations fail to perfectly align is just to say that the mereological relations on some material things and the relative location relations on those material things fail to perfectly align.

The cases of external deviations I am interested in are precisely ones in which there is a two-way mismatch between parthood and contraction, as well as a two-way mismatch between composition and expansion. These are cases in which both $\text{Parts} \Leftrightarrow \text{Contractions}$ and $\text{Fusions} \Leftrightarrow \text{Expansions}$ are violated in both directions. Cases violating the left-to-right direction of $\text{Parts} \Leftrightarrow \text{Contractions}$ —call it $\text{Parts} \Rightarrow \text{Contractions}$ —are ones in which a material thing has parts that are not contractions of it, *i.e.* in which a material thing, x , is part of a material thing, y , but x is exactly located at a region that is not a subregion of the region at which y is exactly located. Cases violating the right-to-left of $\text{Parts} \Leftrightarrow \text{Contractions}$ —call it $\text{Contractions} \Rightarrow \text{Parts}$ —are ones in which a material thing has contractions that are not parts of it, *i.e.* in which a material thing, x , is exactly located at a subregion of the region at which a material thing, y , is exactly located, but x is not part of y . Similarly, cases violating the left-to-right direction of $\text{Fusions} \Leftrightarrow \text{Expansions}$ —call it $\text{Fusions} \Rightarrow \text{Expansions}$ —are ones in which a material object is a fusion but not an expansion of some material things, *i.e.* in which some material things, the x s, compose

a material object, y , but y is exactly located at a region that is not composed of the regions at which the x s are exactly located. And cases violating the right-to-left direction of Fusions \Leftrightarrow Expansions—call it Expansions \Rightarrow Fusions—are ones in which a material object is an expansion but not a fusion of some material things, *i.e.* in which a material object, y , is exactly located at a region composed of the regions at which some material things, the x s, are exactly located, but y is not composed of the x s.

A couple of points about these cases are worth noting. First, Fusions \Leftrightarrow Expansions is stronger than Parts \Leftrightarrow Contractions: Fusions \Rightarrow Expansions entails Parts \Rightarrow Contractions and Expansions \Rightarrow Fusions entails Contractions \Rightarrow Parts. For, on the one hand, if x is part of y , then, by the definition of fusions, y is a fusion of x and y . By Fusions \Rightarrow Expansions, y is an expansion of x and y . But then, by the definition of expansions, x is a contraction of y . On the other hand, if x is a contraction of y , then, by the definition of expansions, y is an expansion of x and y . By Expansions \Rightarrow Fusions, y is a fusion of x and y . So, by the definition of fusions, x is part of y . This shows that the two relevant cases of external deviations are connected: cases violating either direction of Parts \Leftrightarrow Contractions are also cases violating the corresponding direction of Fusions \Leftrightarrow Expansions. Put another way: if parthood fails to be preserved either from some material things to their exact locations, or from some material things' exact locations to those material things, then composition fails to be preserved, too, in the corresponding direction. Or, what amounts to the same: 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 is important to distinguish Contractions \Rightarrow Parts from the following partition principle:

(Partition)

For every subregion of x 's exact location, there exists a part of x that is exactly located at that region.

Clearly, Contractions \Rightarrow Parts does not entail Partition. More interestingly, the converse does not hold either: Contractions \Rightarrow Parts follows from Partition only if co-located material objects are ruled out. By the same token, Contractions \Rightarrow Parts is logically independent from the so-called doctrine of arbitrary undetached parts (Van Inwagen 1981):

(DAUP)

For any region, S , at which x is pervasively located, and any subregion S' of S at which it is metaphysically possible that some material object be entirely located, there exists a part of x that is entirely located at S .

That Contractions \Rightarrow Parts is independent from both Partition and DAUP is important: it helps clarify what exactly Contractions \Rightarrow Parts claims, and distinguishes it from other principles floating around in the literature. In particular, it makes it clear that cases violating Contractions \Rightarrow Parts need not violate Partition or DAUP.

Cases of external deviations in which either direction of either Parts \Leftrightarrow Contractions or Fusions \Leftrightarrow Expansions is violated are highly unintuitive: the misalignments at stake in these cases are very radical, perhaps more so than

those involved in cases violating internal alignment principles. This is most evident in violations of $\text{Parts} \Rightarrow \text{Contractions}$ and hence $\text{Fusions} \Rightarrow \text{Expansions}$, *i.e.* where a material thing is part of another without being a contraction of it, and where some material things compose a material object without expanding into it. These are not cases of scattered objects, at least not as they have been traditionally understood in the literature (see *e.g.* Cartwright 1975). Scattered objects are material things that are exactly located at discontinuous regions, *i.e.* regions that are composed of a plurality of regions at least one of which has no boundaries in common with the rest. To see how scattered objects differ from the kind of material objects violating $\text{Parts} \Rightarrow \text{Contractions}$ and $\text{Fusions} \Rightarrow \text{Expansions}$, consider some arbitrary material things, the *x*s. Assume that at least one of the *x*s is exactly located at a region that has no boundaries in common with the exact location of any other of the *x*s. Let *S* be the discontinuous region that the exact locations of the *x*s compose. Now let *y* be a material thing that is composed of the *x*s and that is exactly located at *S*, and *z* 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 exactly located at a discontinuous region, *i.e.* *S*. Nonetheless, *y* is an expansion of the *x*s: it is exactly located at the fusion of the regions at which the *x*s are exactly located, *i.e.* *S*. By contrast, *z* is not an expansion of the *x*s: by definition, it cannot be exactly located at *S*. Instead, it must be exactly 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 does not overlap *S* altogether. The exact location of *z* need not even be discontinuous.

One might think that cases violating $\text{Contractions} \Rightarrow \text{Parts}$, and hence $\text{Expansions} \Rightarrow \text{Fusions}$, are far less exotic. For instance, consider the example of two mereological simples co-located at a mereologically simple region that I gave in

§1.2.4 above to illustrate that external deviations do not require internal ones. This is a case where $\text{Contractions} \Rightarrow \text{Parts}$, and hence $\text{Expansions} \Rightarrow \text{Fusions}$, are violated: 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 one might think that this is just an old-fashioned case of co-located material objects, where those objects happen to be simples, and where their shared exact location happens to be a simple region. One might then reasonably wonder whether there really is something special about these cases of external deviations.

There are, however, violations of $\text{Contractions} \Rightarrow \text{Parts}$ and $\text{Expansions} \Rightarrow \text{Fusions}$ that make the oddity of the misalignments at hand more apparent. Consider the following principle, according to which in order for a material thing to be proper part of another it is sufficient that the first be a proper contraction of the second:

(Proper-Contractions \Rightarrow Proper-Parts)

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

By the definition of proper contraction, this principle is equivalent to the right-to-left direction of (1-6), and is weaker than $\text{Contractions} \Rightarrow \text{Parts}$ and hence than $\text{Expansions} \Rightarrow \text{Fusions}$. This means that violations of this claim are also violations of $\text{Contractions} \Rightarrow \text{Parts}$, and hence of $\text{Expansions} \Rightarrow \text{Fusions}$.

Violations of Proper-Contractions \Rightarrow Proper-Parts require that a material thing that is exactly located at a proper subregion of the region at which a material object is exactly located not be a proper part of such an object (or a part of that object at all, by Leibniz's Law, since parthood is anti-symmetric). So cases violating this claim do not involve co-location: by the definition of proper contractions, they do not involve

two or more material things sharing their exact location. So they differ from cases like the one of the two co-located simples discussed above.

Violations of Proper-Contractions \Rightarrow Proper-Parts also differ from other kinds of cases discussed in the literature. Suppose, for instance, that someone swallows a rock. This would not violate Proper-Contractions \Rightarrow Proper-Parts. For while the rock is not part of the body, it is not a contraction of the body either: the region at which the rock is exactly located is *not* a subregion of the region at which the body is exactly located. There are, of course, regions at which the body is *entirely* located, which have the same “outer” boundary as the body’s exact location, and which have the rock’s exact location as a subregion. But the body is not *exactly* located at any such region. If you were to draw the body’s exact location, then you could not 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 exact location. In doing so, you would not include the region at which the rock is exactly located as a subregion of the region at which the body is exactly located. By contrast, cases violating Proper-Contractions \Rightarrow Proper-Parts require that a material thing that is not part of another be exactly located at a proper subregion of the region at which the other material thing is exactly located. Similarly, suppose that someone gets shot and the bullet remains stuck inside the victim’s body. This would not violate Proper-Contractions \Rightarrow Proper-Parts either. Like with 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 when we hammer it in. So the region at which the bullet is exactly located is not a subregion of the region at which the body is exactly located. By contrast, there is no displacement in violations of Proper-Contractions \Rightarrow Proper-Parts: a material object is exactly located *within* another material object’s exact location.

Put another way: in violations of Proper-Contractions \Rightarrow Proper-Parts, we have a pair of material objects that are spatiotemporally related to one another in exactly the same way as my arm and my body are related to one another, but that are not mereologically related to one another by parthood in the way that my arm and my body are. Neither the rock nor the bullet in the examples above are spatiotemporally related to the body in the way that my arm is related to my body. Unlike an arm, they are not exactly located at subregions of the body's exact location.

Violations of Proper-Contractions \Rightarrow Proper-Parts differ from yet other cases discussed in the literature. They differ, for instance, from situations in which there is some *stuff* within a material object's exact location, or in which a material thing is exactly located within a material object's exact location but that thing and that object are made out of different matters, which interpenetrate one another. In cases violating Proper-Contractions \Rightarrow Proper-Parts, there is nothing fancy like stuff or interpenetrating matters. All we have, plain and simple, is a material thing that is not part of another, even though it is exactly located at a proper subregion of its exact location.

It is these exotic cases of external deviations that I am interested in: I will be concerned with whether these highly unintuitive violations of both directions of both Parts \Leftrightarrow Contractions and Fusions \Leftrightarrow Expansions are metaphysically possible. As I mentioned above, I will argue that their possibility follows from minimal and otherwise plausible assumptions about modality, part-whole relations, and relations of spatiotemporal location, and that their possibility has a strong bearing on various debates in metaphysics. Let me finish this chapter by sketching the argument and the rest of what I will do here.

1.4 A Sketch of the Argument

I will argue that the metaphysical possibility of the cases of external deviations I am interested in follows from two main assumptions. The first one is an assumption about modality: it is effectively a recombination principle offering sufficient conditions for metaphysical possibility, according to which certain ways of distributing certain sorts of relations are metaphysically possible. The second one is an assumption about the nature of mereological relations and relations of spatiotemporal location, according to which they are among the sorts of relations that the aforementioned recombination principle applies to, and according to which the ways of distributing them so that there are external deviations of the sorts I am interested in are among the ways of distributing them that the principle applies to.

This is in fact the main kind of argument that has been given in favor of the possibility of internal deviations. For instance, McDaniel (2007b) and Sider (2007) argue that the possibility of mereologically simple material things that are exactly located at mereologically complex regions may be established on broadly combinatorial grounds; and McDaniel (2006) argues that the same holds for the possibility of mereologically material objects with simple exact locations and the possibility of gunky material objects with non-gunky exact locations. So what I will suggest here is that this kind of argument cuts much deeper than that: it generalizes for the possibility the radical cases of external deviations I am interested in.

However, the combinatorial argument that I will present differs from those offered in the literature in a crucial respect. Appeals to modal recombination to establish possibilities (or, what it the same, to undermine alleged necessities) are pervasive in

the contemporary literature on metaphysics. Unfortunately, such appeals almost always rest on a poor understanding of modal recombination. On the one hand, issues about modal recombination are run together with related but distinct issues concerning modality, such as modal reduction, the metaphysics of possible worlds, etc. This obscures what exactly is at stake in the relevant appeals to modal recombination. On the other hand, recombination principles are rarely spelled out—most of the time they are only casually stated, and that makes it hard to see exactly what follows from them. Moreover, on the few occasions in which they are more carefully spelled out, they almost always end up being too strong, so that they are clearly objectionable on independent grounds, if not outright false. In showing how the possibility of the cases I am interested in follows from broadly combinatorial considerations, I want to put an end to this trend. I will disentangle issues concerning modal recombination proper from related issues, and suggest a perfectly general and precise way in which recombination principles may be spelled out. This will allow us to single out the principle from which the possibility of the cases I am interested in follows. As we will see, such principle is perfectly general but very weak. This is important because the weaker the assumptions that the possibility of external deviations follows from, the stronger the case for their possibility.

When I say that my main goal here is to show that the metaphysical possibility of external deviations follows from minimal and otherwise plausible assumptions about modality, part-whole relations, and relations of spatiotemporal location, and that those cases have a strong bearing on various metaphysical debates, I mean just that. That is, I am mainly interested in identifying plausible and minimal assumptions from which the possibility of the cases I am interested in follows, and in highlighting some consequences of accepting their possibility, rather than in showing that those

assumptions are in fact true, and that those cases are in fact possible. I am sympathetic to those assumptions, and I will defend them at some length: I will argue that rejecting them requires very radical metaphysical views, perhaps more extreme than accepting the possibility of the cases I am interested in. But that is as far as I will go—I will not further discuss whether one of those views is preferable to accepting the possibility of external deviations. Put another way: I am more interested in showing that the issue of whether external deviations are metaphysically possible leaves us with a choice of unpalatable alternatives, and that one of those alternatives has interesting applications to various metaphysical debates, than in showing that we should accept one of those alternatives over the rest.

Let me conclude with a roadmap of what follows. In chapter 2, I will identify the recombination principle that, together with the relevant assumptions about mereological relations and relations of spatiotemporal location, delivers the metaphysical possibility of the cases of external deviations at issue. As I mentioned above, I will do so by disentangling issues of modal recombination from other ones, and by suggesting a general and precise way in which we may state recombination principles.

In chapter 3, I will do three things. First, I will show how exactly the possibility of our cases follows from this principle and the relevant assumptions about mereology and location. Second, I will defend that principle and those assumptions in the limited sense described above: I will argue that rejecting them requires very radical metaphysical views. Third, I will discuss some general consequences of accepting the possibility of external deviations for a number of debates in metaphysics.

In chapters 4 and 5, I will delve more deeply into the consequences of accepting the possibility of our cases for two debates in the literature. Chapter 4 is concerned

with the debate over persistence over time. I will argue that the possibility of our cases affords a new and compelling objection to an influential argument for temporal parts, the so-called argument from vagueness. Chapter 5 is concerned with the debate over the possibility of mereological indeterminacy. I will argue that given the possibility of our cases both parthood and composition among material objects may be indeterminate without identity, existence, or cardinality being indeterminate. If so, then the possibility of our cases undermines the most influential arguments against the possibility of said indeterminacy given in the literature.

CHAPTER 2
PRINCIPLES OF MODAL RECOMBINATION

My goal in this chapter is to single out the recombination principle that will help us get the metaphysical possibility of the cases of external deviations at issue. Let me begin with some brief remarks about recombination principles in general, and how they are related to a few issues concerning modality and Humeanism.

2.1 Recombination, Modality, and Humeanism

Recombination principles are a family of claims giving sufficient combinatorial conditions for metaphysical possibility: they hold that for such-and-such ways of mixing and matching such-and-such components of reality there exists a corresponding metaphysical possibility. So they are claims of roughly the following form:

- (2-1) For any such-and-such ways of rearranging any such-and-such entities, there exists a metaphysically possible world where those entities are arranged that way.

Different principles differ on what sorts of entities they are concerned with—actual or possible particulars, properties and relations, states of affairs, events, etc.—and what sorts of rearrangements of the relevant sorts of entities are at issue. For instance, consider the following claims:

- (2-2) For any actual particular, x , and any actual property, F , there exists a metaphysically possible world where x is not F .

- (2-3) For any possible particulars, x and y , and any actual two-place relation, R , there exists a metaphysically possible world where x bears R to y .
- (2-4) For any actual two-place relation, R , there exists a metaphysically possible world where R is transitive.
- (2-5) For any possible property, F , and any possible two-place relation, R , there exists a metaphysically possible world where something is not F and bears R to exactly κ F s.

These are all examples of recombination principles. None of them is particularly plausible: it is easy to think of relatively uncontroversial counterexamples to each of them. But they all give sufficient conditions for metaphysical possibility along the lines of (2-1): each claims that for such-and-such entities and such-and-such ways of mixing and matching them, there exists a corresponding metaphysical possibility. (2-2) is concerned with actual particulars, actual properties, and ways of recombining a particular and a property so that the particular does not have the property. So this principle would deliver a possibility in which, for instance, the apple I am eating is not sweet. (2-3) is concerned with pairs of possible particulars and actual two-place relations, and with ways of mixing and matching a pair of particulars and a two-place relation so that one particular bears the relation to the other. So this principle would deliver a possibility in which, for instance, the son that Wittgenstein never actually had but could have had is exactly ten feet away from the third arm that I do not actually have but could have had. (2-4) concerns actual two-place relations, and ways of rearranging a two-place relation so that it is transitive. So it delivers, for instance, a possibility in which being a father of is transitive, *i.e.* in which for any triple of particulars the first is father of the second and the second is father of the third only if

the first is father of the third. (2-5) concerns possible properties and possible two-place relations, and ways of rearranging a property and a two-place relation so that something that lacks the property stands in the relation to any number of things that have the property. So it delivers, for instance, a possibility in which a non-unicorn is less than Planck length from as many unicorns as there are real numbers. (I am assuming possibilist quantification for the sake of these examples, so that the domain of the actual is a proper class of the domain of the possible. But, as will become clear below, principles such as (2-2)-(2-5) are perfectly neutral on issues about actualism vs. possibilism.)

Recombination principles are sometimes thought of in connection with a combinatorial theory of possibility, such as Armstrong's combinatorialism (Armstrong 1989, 1997). A combinatorial theory of possibility aims to be a *reductive* theory of modality: it attempts to reduce all possibilities to ways of mixing and matching elements of other possibilities, in such way that eventually all possibilities trace back to rearrangements of components of only the actual world. Recombination principles are a key element of one such theory: that is how you get possibilities combinatorially. And the success of the theory will depend on finding the right set of principles: those that are collectively strong enough to deliver all the possibilities that there are, but weak enough not to require impossibilities.

It is important to note, however, that recombination principles may hold even if a combinatorial theory of possibility fails at modal reduction. The theory will fail at reducing modality when there are possibilities for which there are not corresponding rearrangements, *i.e.* possibilities that cannot be generated by just mixing and matching elements from other possibilities in some way or other. But all that would mean

is that the set of recombination principles of the theory is incomplete, not that it contains false claims: a principle in the set will be false only if it generates impossibilities, for recombination principles give only sufficient conditions for possibility. So while the principles of the theory might fail to account for all possibilities, all possibilities generated by its principles may be genuine, and so all such principles may be true. Put another way: even if not all possibilities reduce to certain ways of mixing and matching certain things, it may still be true that for certain such rearrangements there exists a corresponding possibility. So recombination principles along the lines of (2-1) may hold even if modality is not reducible to recombination, and so even if a theory like Armstrong's fails.¹ Moreover, recombination principles may be motivated independently of any issues concerning modal reduction: as we will see in chapter 3, there are direct arguments for them that have nothing to do with their playing a role in a reductive theory of modality.

Relatedly, recombination principles are completely neutral on what metaphysics of modality one may favor. For instance, principles along the lines of (2-1) are perfectly compatible with both actualism and possibilism: regardless of whether you think that there are non-actual entities, you may think that certain ways of recombining certain elements of reality are possible. Actualists and possibilists simply disagree, depending on the version of actualism at stake, either on what there is to be recombined, or on the nature of what there is to be recombined. So-called proxy actualists, who believe that although merely possible things do not exist there are proxies for them (*e.g.* Plantinga 1974; Linsky and Zalta 1994, 1996; Williamson 1998, 1999; the label is due to Bennett 2006), disagree with possibilists about the nature of some recombinables, such as Wittgenstein's possible son. So-called strict actualists,

¹For compelling reasons why recombination fails at reducing modality, see Sider 2005.

who believe that there are neither merely possible things nor proxies for them (*e.g.* Prior 1957, Adams 1981, Menzel 1990), disagree with possibilists as to whether such things as Wittgenstein's possible son are in any way among the recombinable. But they may all nonetheless believe that for some ways of mixing and matching some things there is a corresponding metaphysical possibility. Similarly, principles along the lines of (2-1) are perfectly compatible with different views on the nature of possible worlds. Regardless of what you think that possible worlds are—concrete things, sets of propositions, fictions, rearrangements, etc.—you may believe that for certain ways of rearranging certain sorts of entities there exist metaphysically possible worlds where those entities are arranged that way. Thus, recombination principles may hold independently of all these issues in the metaphysics of modality—they are in principle resilient to the success or failure of any particular view on these matters.

It follows that recombination principles are independent of issues concerning modal reduction, as well as the metaphysics of modality. An important consequence of this is that one may not in general reject recombination principles on the grounds that they fail to do such-and-such work in reducing modality, or that they are somehow in tension with some particular view in modal metaphysics. Such objections would be misguided—they would fail to recognize recombination principles for what they are, *i.e.* claims giving merely sufficient conditions for metaphysical possibility.

Recombination principles are also sometimes thought of in connection with Humeanism, the doctrine that there are no necessary connections between distinct existences.² One may distinguish between different versions of Humeanism, depend-

²Two views tracing back to Hume are called *Humean* these days: the view that there are no necessary connections among distinct existences (see *e.g.* Lewis 1986, pp. 87-8), and the view that all the facts of a world supervene on the spatiotemporal distribution of local qualities (see *e.g.* Lewis 1994). These two views are in principle independent from one another. One might think, for instance, that there are no necessary connections among distinct existences, and still believe that, say, causation does not supervene

ing on what sorts of entities are at stake, what notion of distinctness is at issue, and what kind of connection it is denied that the relevant entities necessarily stand in. Consider, for instance, the following two claims:

- (2-6) For any actual particulars, x and y , that actually do not mereologically overlap, and any possible properties F and G , it is not necessary that x be F only if y is G .
- (2-7) For any possible properties, F and G , that actually stand in no determinate-determinable relation to one another, it is not necessary that there be exactly κ F s only if there are exactly κ' G s.

These two claims differ on what entities they are concerned with, what notion of distinctness is involved, and what necessary connection is at stake. (2-6) concerns pairs of actual particulars, mereological distinctness, and a certain form of qualitative dependence across modal space. And (2-7) is concerned with pairs of possible properties, determinable distinctness, and a certain form of instantiational dependence across modal space. Nonetheless, (2-6) and (2-7) are both Humean: they both claim that any entities of such-and-such sort that are distinct from one another in such-and-such way are not necessarily tied to one another in such-and-such manner. That is, they are both variations on the following Humean schema:

- (2-8) For any such-and-such entities that are distinct from one another in such-and-such way, it is not necessary that they be connected to one another in such-and-such way.

on the spatiotemporal distribution of any local qualities. Similarly, one might think that causation, etc. supervene on the spatiotemporal distribution of such-and-such local qualities, and still believe that there are necessary connections among distinct entities. Recombination principles are directly connected to Humeanism understood of in the former way; their ties to Humeanism understood in the latter way are much less straightforward, and not relevant to my purposes here.

From this it is easy to see how Humeanism is related to modal recombination: each Humean claim along the lines of (2-8) is equivalent to some recombination principle along the lines of (2-1), for each such claim effectively requires that for any such-and-such ways of rearranging any such-and-such entities there exist a possible world where those entities are arranged that way. This means that some recombination principles are effectively Humean, *i.e.* require that there be no necessary connections of such-and-such sort among entities of such-and-such kind which are distinct from one another in such-and-such way. As we will see, the recombination principle that will help deliver the possibility of external deviations is a Humean one: it effectively denies a certain form of necessary connection among a certain sort of actual first-order relations, which are distinct from one another in a certain way. It is important to note, however, that not all recombination principles need be Humean. For instance, there is nothing Humean about a claim like (2-4), since it concerns only single relations, and hence cannot apply to entities that may be distinct from one another in some way or other. This suggests that some recombination principles may hold independently of any issues concerning Humeanism.

Another point concerning Humeanism is worth noting. Humeans are often said to be suspicious of “mysterious” necessary connections among things. Claims along the lines of (2-8) entail that if there are necessary connections among some entities, then such entities must fail to be distinct from one another in some relevant way. So these claims do in fact suggest that if there were necessary connections among relevantly distinct things, then such connections would be mysterious—they would seem to come out of nowhere. However, it is important to distinguish between two reasons why one may think that such connections are mysterious. First, one might think that accepting necessary connections among relevantly distinct things is tan-

tamount to accepting irreducible modal facts, *i.e.* that nothing grounds or explains that it is necessary that so and so. From this perspective, such necessary connections would come out of nowhere in the sense that they would not be grounded on the non-modal. Second, one may think that it is independently plausible that there are no necessary connections between relevantly distinct things, *i.e.* that it is *prima facie* possible that such things not be related to one another in the relevant way. From this perspective, such necessary connections would come out of nowhere in the sense that there would be no good reason to believe in them.

Contrary to what is often assumed in the literature (see deRosset 2009 for discussion), it would be odd for Humeans to think that necessary connections between relevantly distinct entities are mysterious for the first reason, *i.e.* because of worries about modal reduction. For as we have seen, in holding claims along the lines of (2-8) Humeans not only deny certain necessities, but also effectively postulate certain possibilities. And one may worry about the irreducibility of those possibilities to exactly the same extent that one may worry about the irreducibility of those necessities. For instance, consider the claim—contra (2-6)—that it is necessary that the apple I am eating be sweet only if Socrates is a philosopher. It would be strange for the Humean who holds (2-6) to be suspicious of this necessity qua modal fact, *i.e.* on the grounds that nothing would explain why the apple and Socrates are related to one another that way across modal space. For in holding (2-6) and in denying such necessity, she effectively holds that it is possible that the apple I am eating be sweet without Socrates's being a philosopher. And one may be suspicious of this possibility qua modal fact on the same grounds as one may worry about the necessity qua modal fact, *i.e.* on the grounds that nothing would explain why my apple and Socrates are related to one another this way across modal space. Put another way: the Humean and her opponent

disagree simply disagree about how certain entities are related to one another across modal space, *i.e.* about whether this or that modal fact holds. The question of what, if anything, explains that such-and-such entities are or are not related to others in such-and-such ways across modal space, *i.e.* of what explains that this or that modal fact holds, is a completely different issue, which should concern the Humean no less than it should concern her opponent. So if the Humean is suspicious of this necessary connection between the apple and Socrates, it must be simply because she has independent reason to think that the apple and Socrates are not tied to one another that way across modal space, *e.g.* she may hold a substantive view about the nature of the apple on which its essence involves no facts extrinsic to it.

This suggests that Humeanism is independent of issues concerning modal reduction. This is important not only given that, as I mentioned above, it is often assumed otherwise, but also in light of two points I suggested above: that recombination principles are independent of issues regarding modal reduction, and that the Humean doctrine that there are no necessary connections among distinct existences is simply the view that certain recombination principles are true.

Now, another reason why recombination principles have generated a lot of interest in the recent literature is that they have sometimes been thought of as purported tools of modal discovery. As I have emphasized, recombination principles (both Humean and non-Humean) offer sufficient conditions for metaphysical possibility, and hence posit possibilities and rule out necessities. So, if true, they tell us about what is possible and what is not necessary. In fact, Lewis goes as far as saying that certain recombination principles (Humean ones, in the spirit of (2-6)) give us “our *best* handle on the question of what possibilities there are” (2001, p. 611, em-

phasis added). It is precisely in this respect, *i.e.* qua tools of modal discovery, that recombination principles are relevant to the issue of whether the cases of external deviations I am interested in are metaphysically possible. It would follow that they are metaphysically possible if there were an independently plausible recombination principle according to which we may mix and match some things in some relevant way.

However, all the potential interest of recombination principles qua purported tools of modal discovery has been shadowed by the fact that they have so far proven elusive of systematic treatment. As Sider (2000) and Hudson (2007) have remarked, the important task of systematizing them is far from trivial. On the one hand, it is hard to precisely formulate many principles without making them either too strong or too weak to be philosophically interesting, *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. On the other hand, it is hard to draw principled distinctions among different recombination principles, so that it is not arbitrary that some such principles hold but not others. That is, it is hard to independently motivate why such-and-such entities may be recombined in certain ways but not others, or why certain entities but not others may be recombined in such-and-such ways. Without independent motivation, it would be ad-hoc to think that some given recombination principle is true, but that a slightly stronger yet clearly implausible one is not.

For instance, Lewis cashes a Humean recombination principle particularly important for many of his philosophical views as the claim that “anything can coexist

with anything else [and] anything can fail to exist with anything else,” as well as the claim that “patching together parts of different possible worlds yields another possible world” (Lewis 1986, pp. 87-8). These formulations are suggestive, but they make it very hard to see what exactly these principles entail. Moreover, they make it very hard to see whether they make the same claim, as Lewis assumes; *prima facie*, the first principle seems to concern recombination of particulars, while the second seems to concern recombination of states of affairs. And as the literature on these issues makes clear, it is actually very hard to formulate these principles without collapsing them into either clearly false or clearly trivial claims. (2-6), for instance, is precise and non-trivial, but is arguably false, as well as far from general enough for Lewis’s purposes.

Given these difficulties for systematizing recombination principles, it is reasonable to be suspicious of appeals to them *qua* tools of modal discovery. I believe, however, that these difficulties can be addressed. In what follows I will suggest a general strategy to precisely formulate recombination principles, which will allow us to see exactly what each of them entails and how they are related to one another. And I will suggest principled distinctions that may be drawn among different principles, which will allow us to see that it is not *ad hoc* to think that some principles are true but that closely related ones are not. I will show in detail how this may be done to single out the principle that we are interested in here, *i.e.* the one that will help us get the possibility of the cases of external deviations at issue. But the general strategy I suggest allows us to systematize other sorts of recombination principles.

2.2 Possibly True Second-Order Sentences

What we are after is a recombination principle according to which we may mix and match things so that there are external deviations of the sort we are interested in. Remember that recombination principles differ on the kinds of entities and on the ways of rearranging those entities they recombine. The principle we are looking for concerns *actual, first-order properties and relations* and certain ways of rearranging them: it claims that for certain ways of mixing and matching certain actual first-order properties or relations there exists a corresponding metaphysical possibility. Principles of this sort are sometimes expressed along the following lines (I leave the restriction to *actual* first-order properties and relations implicit from here on):

(2-9) Any such-and-such pattern of instantiation of any such-and-such first-order properties or relations is metaphysically possible.

What exactly is a pattern of instantiation of some first-order properties or relations? That is, what exactly is a way of rearranging or of mixing and matching some first order properties or relations? Roughly, a pattern of instantiation of a single first-order property or relation is a way in which such property or relation may be distributed over some particulars. For instance, being red may be instantiated so that there are exactly three red things, or so that there are at least seven red things, or so that there are at most two red things, or so that everything is red, or so that there is at least one red thing and at least two things that are not red, or so that every red thing bears some relation to another red thing, etc. Similarly, a pattern of instantiation of a plurality of first-order 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 so that there is at least one red thing and everything is exactly two feet away from everything else, or so that every red thing is exactly two feet away from something that is not red, or so that every red thing that bears some relation to an object that is not red is exactly two feet away from that object, etc. So principles along the lines of (2-9) just claim that for certain ways of instantiating certain first-order properties and relations, it is metaphysically possible that those properties and relations be instantiated in those ways.

Notice that we may express that a first-order property or relation is instantiated so that so-and-so with a sentence of an artificial second-order language that has a predicate for that first-order property or relation, where such sentence claims (extensionally) that so-and-so. For instance, we may express that being red is instantiated so that every red thing bears a two-place relation to another red thing with a sentence such as ' $\forall x(Rx \rightarrow \exists y \exists X(x \neq y \ \& \ Ry \ \& \ Xxy))$ ', where 'R' expresses (denotes, stands for, etc.) being red. Similarly, we may express that a plurality of first-order properties or relations are instantiated so that so-and-so with a sentence of an artificial second-order language that has predicates for those first-order properties or relations, where such sentence claims that so-and-so. For instance, we may express that being red and being exactly two feet away from are instantiated so that every red thing is exactly two feet away from something that is not red with a sentence such as ' $\forall x(Rx \rightarrow \exists y(\neg Ry \ \& \ Axy))$ ', where 'R' and 'A' express being red and being exactly two feet away from, respectively.

Given this natural correspondence between patterns of instantiation of some given properties or relations and sentences of sufficiently expressive languages that have predicates for those properties or relations, we may trade talk about such patterns

for talk about such sentences. This suggests that we may formulate recombination principles for first-order properties and relations along the following lines, instead of along the lines of (2-9): for any such-and-such sentences of a second-order language with occurrences of such-and-such predicates, there exists a metaphysically possible world where that sentence is true.

Here is a more concrete picture of how this might go. Suppose that L is a second-order language with standard logical vocabulary (first- and second-order variables, quantifiers, the identity symbol, and the truth-functional connectives) and a stock of first-order predicates (L has no individual constants or second-order predicates). Let's assume that every n-place first-order predicate of L expresses exactly one n-place first-order property or relation, and that every n-place first-order property or relation is expressed by exactly one n-place first-order predicate of L.³ Then we may state recombination principles for first-order properties and relations along the following lines:

- (2-10) For any such-and-such predicates $\Pi_1^{i_1}, \dots, \Pi_n^{i_n}$ of L and any such-and-such well-formed formula $\phi(X_1^{i_1}, \dots, X_n^{i_n})$ of L, there is a metaphysically possible world where $\phi(\Pi_1^{i_1}, \dots, \Pi_n^{i_n})$ is true,

where superscripts indicate adicity, each $X_j^{i_j}$ is a second-order variable, $\phi(X_1^{i_1}, \dots, X_n^{i_n})$ has at least one free occurrence of each $X_j^{i_j}$ but no free occurrences of first-order variables, and $\phi(\Pi_1^{i_1}, \dots, \Pi_n^{i_n})$ is the sentence of L we get by replacing every free occurrence of each $X_j^{i_j}$ in $\phi(X_1^{i_1}, \dots, X_n^{i_n})$ with exactly one occurrence of $\Pi_j^{i_j}$. (2-10) just says that for every sentence of L that has occurrences

³I 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.

of predicates expressing such-and-such first-order properties or relations of any adicity whatever and that claims that those properties or relations are instantiated in such-and-such way, there is a possible world where that sentence is true. In quantifying over such-and-such predicates L, principles along the lines of (2-10) will concern such-and-such first-order properties or relations. And in quantifying over such-and-such well-formed formulas of L, they will concern such-and-such patterns of instantiation of first-order properties or relations.

Formulating recombination principles along the lines of (2-10) instead of along the lines of (2-9) has several advantages. It makes their logical form perfectly transparent. It also makes talk of the somewhat slippery notion of a rearrangement (or a way of mixing and matching, or a pattern of instantiation, or distribution of) first-order properties or relations perfectly rigorous, for it converts it into talk of sentences of a language with well-defined properties. Moreover, it will make it very easy to specify the character and complexity of a given pattern of instantiation of some properties or relations, for this will be revealed in the logical form of the relevant sentences of the language. It will also make it very easy to distinguish between different recombination principles and understand the relations between them, for different principles will set different restrictions on which sentences of L have a possible world at which they are true. Finally, it has another sort of advantage: it makes recombination principles for first-order properties or relations nominalist-friendly. For even if you think that there are no first-order properties or relations, and hence no rearrangements of these, you may think that any such-and-such sentences with occurrences of any such-and-such predicates are possibly true.

It is worth noting a couple of points about L, however. First, one might think that there are more actual first-order properties and relations than a language like L may have predicates for, and so there could not be a language with the properties we have attributed to L. For instance, one might think that for every real number, r , something that is exactly r feet long actually exists. But one might be convinced that a language like L could not have as many predicates as there are real numbers, given familiar objections to languages with more than denumerably many expressions. I am not convinced that those objections are serious. But even if they are, we may just assume that there is a one-one correspondence between the predicates of L and the first-order properties and relations we normally care about—being a dog, being red, being an electron, being exactly q feet long for any rational number q , being part of, etc. For our purposes, it will not matter if L lacks a predicate for, say, having mass of exactly $\sqrt{2}$ nanograms.

Second, one might think that for our purposes we do not need a second-order language, but only a first-order one. After all, L has no second-order predicates; why would we need quantification over first-order properties and relations? The reason is that certain patterns of instantiation of first-order properties and relations are not expressible with only first-order resources. For a simple case, consider an example we already looked at above: that being red is instantiated so that every red thing bears a two-place relation to another red thing cannot be expressed without second-order quantification. For other cases, notice that second-order quantification is required in order to express, say, that a relation is well-founded, or that some first-order property is instantiated so that there are uncountably many things with that property. So in order not to constrain from the get-go what sorts of possibilities recombination principles along the lines of (2-10) may in principle deliver, a second-order language is preferable.

Given this general strategy for formulating recombination principles for first-order properties and relations, let us now single out the principle that will help deliver the possibility of the cases at external deviations at issue.

2.3 Recombination Unbound

Different recombination principles along the lines of (2-10) set different restrictions on what kinds of first-order properties and relations may be recombined, and on what ways those first-order properties and relations may be recombined. Clearly, the more liberal a principle is, the stronger it is; that is, the more first-order properties and relations a principle is about, and the more ways of instantiating them it concerns, the more possibilities it delivers. The cases of external deviations at issue require only a very weak principle, which concerns only some first-order relations and only some ways of instantiating them; *i.e.* it applies to only a very specific class of sentences of L. It will be useful to introduce this principle by placing restrictions on stronger ones.

Let's begin with a completely unbound principle:

(2-11) For any predicates $\Pi_1^{i_1}, \dots, \Pi_n^{i_n}$ of L and any well-formed formula $\phi(X_1^{i_1}, \dots, X_n^{i_n})$ of L, there is a metaphysically possible world where $\phi(\Pi_1^{i_1}, \dots, \Pi_n^{i_n})$ is true.

This is a very strong principle: it claims that *every* sentence of L is true at some possible world, *i.e.* that *any* first-order properties or relations whatsoever may be recombined in *any* way whatsoever. And it is clear that (2-11) is in fact *too* strong. It entails, for instance, 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 red without having a property, that something be made out of water without being made out of H₂O, 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. For there are sentences of L with occurrences of predicates expressing the relevant properties and relations that require that they be instantiated in the relevant ways.

These consequences of (2-11) make it clear that recombination of first-order properties and relations must be constrained somehow: a principle like (2-11) is just absurd. At the same time, what we need are *principled* restrictions on recombination, *i.e.* non-ad hoc ways of distinguishing between those first-order properties and relations that may be recombined and those that may not, as well as between those ways in which recombining first-order properties and relations may be recombined and those in which they may not. In other words, we need to single out weakenings of (2-11) that apply to *all* entities satisfying a certain well-motivated condition, and to *all* ways of recombining those entities that satisfy an also well-motivated condition. Otherwise it would be unacceptably arbitrary to say that *these* but not *those* first-order properties or relations may be recombined, or that they may be recombined in *this* but not *that* way. Let's see how this may be done.

2.4 Logic and Determinable-Distinctness

A first well-motivated restriction has to do with logic: an obvious problem with (2-11) is that it entails logical falsehoods. So one may constrain recombination as follows: any first-order properties and relations may be recombined in any *logically consistent* way. This would be to weaken (2-11) so that only sentences of L that have a model be true at some possible world, where a model is a familiar set-theoretic structure. Notice that this constraint does not require the somewhat controversial view that equates logical truth with model-theoretic validity. All it requires is the uncontroversial claim that model-theoretic invalidity is sufficient for logical falsehood.

This restriction suffices to avoid many of the unwanted consequences mentioned above, *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 red without having a property, that something be made out of water without being made out of H₂O, etc. For in these cases it is logically inconsistent that the relevant first-order properties and relations be instantiated in the relevant ways—the corresponding sentences of L do not have a model. This includes cases of a posteriori identities between properties, such as being made out of water and being made out of H₂O: a sentence of L requiring that these properties not be identical does not have a model, because these properties are identical and we have stipulated that L has no more than one predicate for any given property or relation.

However, this restriction alone does not suffice to rule out other unwelcome consequences of (2-11), *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 relevant first-order properties and relations be instantiated in the relevant ways—there are models of the corresponding sentences of L. So further restrictions on recombination are needed—logic alone is not enough.

A salient feature of the remaining undesirable consequences of (2-11) is that they involve first-order 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 we may avoid the remaining problem cases by placing a restriction on recombination concerning determinates and determinables. Such a restriction would not be ad hoc, since that first-order properties and relations necessarily stand in relations of determinate and determinable to one another may be independently motivated. So, let's say that a pair of first-order properties or relations are *determinably-distinct* just in case they stand in no determinate-determinable relation to one another. That is, for any first-order properties or relations, F and G:

(Determinable-Distinctness)

F and G are determinably distinct \equiv_{df} F is not a determinate of G, G is not a determinate of F, and there is no H that both F and G are determinates of.⁴

⁴Of course, this is to be construed so that being a property and being a relation do not count as determinables. For then trivially no two properties and no two relations would be determinably distinct.

Then we may restrict recombination as follows: any pairwise determinably-distinct first-order properties or relations may be recombined in any logically consistent way.

This would be to weaken (2-11) as follows:

(2-12) For any predicates $\Pi_1^{i_1}, \dots, \Pi_n^{i_n}$ of L that express pairwise determinately-distinct first-order properties or relations, and any predicate-free formula $\phi(X_1^{i_1}, \dots, X_n^{i_n})$ of L, if $\phi(\Pi_1^{i_1}, \dots, \Pi_n^{i_n})$ has a model, then there is a metaphysically possible world where $\phi(\Pi_1^{i_1}, \dots, \Pi_n^{i_n})$ is true.

The requirement that $\phi(X_1^{i_1}, \dots, X_n^{i_n})$ be predicate-free is important: without it, $\phi(X_1^{i_1}, \dots, X_n^{i_n})$ may have occurrences of predicates other than $\Pi_1^{i_1}, \dots, \Pi_n^{i_n}$ for non-determinably distinct first-order properties or relations, making the intended restriction useless.

(2-12) seems to be the most liberal recombination principle for first-order properties and relations that is not downright implausible. It is powerful enough to generate many possibilities, but it is weak enough not to entail any of the unwanted possibilities above.

2.5 Fundamentality

The logic and determinable-distinctness constraints on recombination suffice to avoid the most obvious undesirable consequences of (2-11). But they are not enough to deal with another class of alleged necessities: those concerning first-order properties and relations that are *more fundamental* than others. Fundamentality is about relative position in a priority ordering over the components of reality, such that facts

about less fundamental entities are grounded on or explained by facts about more fundamental ones. Some philosophers think that some first-order properties and relations are more fundamental than others, whereby facts about less fundamental ones are grounded on facts about more fundamental ones. For instance, some philosophers think that neural properties are more fundamental than mental properties, and that facts about the latter are grounded on facts about the former. Similarly, some philosophers 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. Some of those philosophers also think that facts about fundamentality and grounding are metaphysically necessary, and so that less fundamental properties and relations could not be instantiated without more fundamental ones being instantiated as well. But since less and more fundamental first-order properties and relations need not stand in determinate-determinable relations to one another, and since it is logically consistent that less fundamental properties and relations be instantiated without the more fundamental ones being instantiated, such philosophers would think that further constraints on recombination are needed.

Although all these claims are highly controversial, nothing is lost by restricting recombination so that it remains compatible with all the relevant necessities. This may be achieved by constraining it to those first-order properties and relations at the very bottom of the priority ordering, *i.e.* to those properties and relations facts about which are not grounded on facts about other properties and relations. Let's call such first-order properties and relations *the* fundamental ones.⁵ Adding this constraint to the

⁵There are different ways of accounting for fundamentality in the literature (see *e.g.* Fine 1994, 2001; Sider 2009, MS; Schaffer 2009, MSa; Rosen MS), but they all postulate a fundamental level. And, of course, the present constraint on recombination is neutral on how exactly fundamentality is to be ultimately cashed out.

previous two, we may restrict recombination as follows: any fundamental, pairwise determinably-distinct first-order properties or relations may be recombined in any logically consistent way. This would be to restrict (2-12) as follows:

- (2-13) For any predicates $\Pi_1^{i_1}, \dots, \Pi_n^{i_n}$ of L that express fundamental, pairwise determinably-distinct first-order properties or relations, and any predicate-free formula $\phi(X_1^{i_1}, \dots, X_n^{i_n})$ of L, if $\phi(\Pi_1^{i_1}, \dots, \Pi_n^{i_n})$ has a model, then there is a metaphysically possible world where $\phi(\Pi_1^{i_1}, \dots, \Pi_n^{i_n})$ is true.

Notice that, without further assumptions, the determinable-distinctness restriction is not redundant given the fundamentality one. One may think, for instance, that having mass and having mass of exactly one gram are both fundamental.

(2-13) is surely more plausible than (2-11) and (2-12). It is also strong enough for our purposes: it entails that cases of external deviations are possible together with the assumptions that material thinghood, regionhood, our primitive parthood relation, and our primitive relation of spatiotemporal location are both fundamental and pairwise determinably-distinct. For it is logically consistent that parthood, spatiotemporal location, material thinghood, and regionhood be instantiated in the relevant ways. That is, 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 deviations.

However, (2-13) and those assumptions also entail other possibilities. For instance, they entail that it is possible that parthood fail to be reflexive, as well as that it may fail to be transitive, since it is logically consistent that parthood be instantiated in the relevant ways—there are models of corresponding sentences of L. Similarly, they

entail that gunky material objects are possible, as well as that any view on when some material things compose a material object is contingent, since it is logically consistent that parthood and material thinghood be instantiated in the relevant ways—there are models of corresponding sentences of L. By the same token, they entail that gunky regions are possible, as well as that any view on when some regions compose a region is contingent, since it is logically consistent that parthood and regionhood be instantiated in the relevant ways—there are models of corresponding sentences of L. (2-13) and those assumptions also entail that co-located material objects are possible, since it is logically consistent that parthood, location, material thinghood, and regionhood be instantiated in the relevant ways—there are models of corresponding sentences of L. They also entail that it is possible that there be any countable number of material objects, as well as that there be uncountably many of them, since it is logically consistent that material thinghood be instantiated in the relevant ways—there are models of corresponding sentences of L.

It is highly controversial whether any of the situations above is metaphysically possible. In fact, there is plenty of independent motivation to reject that some of them are possible, such as situations in which parthood fails to be transitive. So in order to make a strong case for the possibility of external deviations, it would be desirable to have either a weaker recombination principle or weaker assumptions, which entailed the possibility of external deviations without entailing any of the other possibilities. Moreover, not only would it be desirable to weaken either (2-13) or the assumptions above to that effect, but also that they *must* be weakened somehow. For in addition to the controversial possibilities above, they require some outright implausible possibilities. For instance, they entail that it is possible that a material object be located nowhere, since it is logically consistent that parthood, location, material thinghood,

and regionhood be instantiated in the relevant way, since there are models of corresponding sentences of L.

So that we get the possibility of external deviations without any of the other possibilities above, I believe a two-prong strategy is required: (2-13) has to be weakened, but in addition our assumptions about parthood, location, material thinghood and regionhood have to be weakened in some ways and strengthened in others. For now let us see how (2-13) ought to be further restricted. In chapter 3, I will show how our assumptions about parthood, location, material thinghood, and regionhood have to be modified.

2.6 Varieties of Second-Order Anti-Essentialism

It is hard to see exactly how further principled restrictions on (2-13) may be placed—doing so would seem to require hand-picking certain fundamental determinably-distinct first-order properties and relations over others, or certain patterns of instantiation of first-order properties and relations over others. And that seems intolerably arbitrarily. But I believe that there actually are non-ad hoc ways of weakening (2-13). The key is to think about second-order properties and relations.

Notice that one may think of a first-order property or relation being instantiated so that so-and-so as that first-order property or relation having such-and-such second-order property. For instance, if a first-order two-place relation is instantiated so that no two things mutually stand in that relation to one another, we may think of such first-order relation as having a certain second-order property (we even have a name for that second-order property: *anti-symmetry*). Similarly, one may think of some

first-order properties or relations being instantiated so that so-and-so as those first-order properties or relations standing in such-and-such second-order relation to one another. For instance, if a first-order property and a first-order two-place relation are instantiated so that a thing has that property and stands in that relation to some object only if that object also has that property, then one may think of that first-order property and that first-order relation as standing in a certain second-order relation to one another (per Frege 1879, we also have a name for that second-order relation: *hereditariness* of a property on a relation). Accordingly, one may think of a certain sentence of L with occurrences of a single predicate as claiming that the first-order property or relation expressed by such predicate has a certain second-order property. And one may think of a certain sentence of L with occurrences of more than one predicate as claiming that the plurality of first-order properties or relations expressed by those predicates stand in a certain second-order relation to one another.

Now, just as one may think that some first-order properties and relations are essential to the particulars that have and stand in them, one may think that some second-order properties and relations are essential to the first-order properties and relations that have and stand in them. That is, just one may be an essentialist about particulars, one may be an essentialist about first-order properties and relations. Call the view that some first-order properties and relations are essential to the particulars that have and stand in them *first-order essentialism*. Similarly, call the view that some second-order properties and relations are essential to the first-order properties and relations that have and stand in them *second-order essentialism*. Like first-order essentialism, second-order essentialism comes in different strengths: one might think that all second-order properties and relations are essential to their first-order bearers and relata, or that only some of them are.

From this it is clear that recombination principles like (2-11)-(2-13) are in effect *anti-essentialist* claims about first-order properties and relations: they require that certain second-order properties and relations *not* be essential to their first-order bearers and relata. In fact, the stronger the recombination principle, the stronger the form of second-order anti-essentialism it requires, and the weaker the form of second-order essentialism the principle is compatible with. And the weaker the recombination principle, the weaker the form of second-order anti-essentialism it requires, and the stronger the form of second-order essentialism it is compatible with. (2-13) is then a very strong second-order anti-essentialist principle: it requires that pretty much no second-order property or relation be essential to its first-order bearers and relata. (2-13) is compatible with only a very weak form of second-order essentialism, according to which only trivial second-order properties and relations—those corresponding to sentences of L that are model-theoretic validities—may be essential to their first-bearers and relata.⁶

There are two main reasons why (2-13) is such a strong second-order anti-essentialist principle. First, (2-13) does not distinguish between second-order *properties* and second-order *relations*. For any fundamental determinably-distinct first-order properties or relations, (2-13) requires that they have no essential second-order properties to exactly the same degree that it requires them to stand in no essential second-order relations to one another. But it is important to distinguish between two forms of second-order anti-essentialism here. On the one hand, one might think that

⁶Of course, here I am considering only *extensional* second-order properties and relations, *i.e.* those second-order properties and relations that may be expressed by sentences of a second-order language without second-order predicates. (2-13) is neutral on *intensional* second-order properties and relations, *i.e.* those that may only be expressed using second-order predicates. For all (2-13) says, every intensional second-order property and relation may be essential to its first-order bearers and relata. For instance, (2-13) is compatible with the claim that having unit negative charge has the second-order properties of being fundamental and of being my favorite property essentially.

first-order properties and relations stand in no non-trivial essential second-order relations to one another, but remain neutral as to whether they have any non-trivial essential second-order properties. On the other hand, one might think that first-order properties and relations have no non-trivial essential second-order properties, but remain neutral as to whether they stand in any non-trivial essential second-order relations to one another. The distinction between these two forms of second-order anti-essentialism is parallel to a distinction between two forms of first-order anti-essentialism. On the one hand, one might think that no non-trivial first-order relation among particulars is essential to them, but remain neutral as to whether particulars have non-trivial essential first-order properties. On the other hand, one might think that no particular has non-trivial essential first-order properties, but remain neutral as to whether particulars stand in any non-trivial first-order relations essentially.

The distinction between these two more moderate forms of second-order anti-essentialism suggests a principled distinction between two versions of (2-13): one that is anti-essentialist about second-order relations but remains neutral about second-order properties, and one that is anti-essentialist about second-order properties but remains neutral about second-order relations. The former claims that any fundamental determinably-distinct first-order properties or relations may be instantiated *together* in any way that is compatible with those ways in which each such property or relation must be instantiated *on its own*, whatever those ways may be. The latter claims that any fundamental determinably-distinct first-order properties or relations may be instantiated *on their own* in any way that is compatible with those ways in which they must be instantiated *together*, whatever those ways may be.

The second reason why (2-13) is a very strong second-order anti-essentialist principle is that, just as it does not distinguish between properties and relations in the second-order case, it does not distinguish between them in the first-order case either. But one may insist that distinguishing among the latter is as important as distinguishing among the former, in so far as different anti-essentialist views are concerned. So, on the one hand, one might think that no first-order properties have or stand in any non-trivial second-order properties or relations essentially, but remain neutral as to whether first-order relations do. On the other hand, one might think that no first-order relations have or stand in any non-trivial second-order properties or relations essentially, but remain neutral as to whether first-order properties do. The distinction between these two views has no analogue for particulars: there is no feature of particulars corresponding to adicity. Still, one may motivate the distinction between these two views by thinking about particulars. For instance, one might think that no first-order relations among elementary particles are essential to them, but that it is essential to an elementary particle that it have a *cluster* of various first-order properties (mass, charge, spin, etc.). This would be to think that certain non-trivial second-order relations are essential to certain first-order properties (nothing can be an elementary particle without having mass, charge, spin, etc.), but that no non-trivial second-order relations are essential to first-order relations.

The distinction between these two further forms of second-order anti-essentialism suggests a principled distinction between two further versions of (2-13): one that concerns first-order properties but remains neutral about first-order relations, and one that concerns first-order relations but remains neutral about first-order properties. According to the former, any fundamental determinably-distinct first-order properties may be instantiated (together or alone) in any way that is compatible with those

ways in which fundamental determinably-distinct first-order relations must be instantiated (together or alone), whatever those ways may be. According to the latter, any fundamental determinably-distinct first-order relations may be instantiated (together or alone) in any way that is compatible with those ways in which fundamental determinably-distinct first-order properties must be instantiated (together or alone), whatever those ways may be.

From the above it is clear that one may distinguish between further essentialist and anti-essentialist views about first-order properties and relations, which would allow one to distinguish between further principled weakenings of recombination principles like (2-11)-(2-13). In particular, one may devise a view that is anti-essentialist about *only* second-order relations among *only* fundamental determinably-distinct first-order relations, which remains neutral about everything else. This is a view according to which no non-trivial second-order relation is essential to any fundamental determinably-distinct first-order relations, but which remains silent as to whether any other non-trivial second-order properties and relations are essential to their first-order bearers and relata. The recombination principle corresponding to this view claims that any fundamental determinably-distinct first-order relations may be instantiated together in any way that is compatible with (i) those ways in which each such relation must be instantiated on its own, (ii) those ways in which each such relation must be instantiated together with any first-order properties or non-fundamental relations, and (iii) those ways in which any first-order properties or non-fundamental relations must be instantiated either together or on their own, whatever all such ways may be. This is the principle we are looking for, which will deliver the possibility of the cases of external deviations at issue without any of the other controversial or implausible consequences of (2-13).

Let's then formulate our principle. First, it cannot be stated by simply restricting (2-13) to those predicates of L expressing fundamental, pairwise determinably-distinct first-order relations, and to those predicate-free formulas of L that have free occurrences of two or more second-order variables. For, on the one hand, such principle would not be neutral as to whether fundamental first-order relations have any essential second-order properties, and so would still deliver some of the controversial consequences of (2-13). For instance, together with the assumption that parthood and location are fundamental and determinably-distinct, such principle would still entail that it is possible that parthood fail to be both reflexive and transitive, that gunk is possible, etc., since there are corresponding sentences of L with only the predicates for parthood and location. On the other hand, such principle would deliver possibilities in which *only* parthood and location are instantiated together, not possibilities in which parthood, location, material thinghood, and regionhood are *all* instantiated together, as cases of external deviations require. So our principle calls for a more subtle formulation.

Here is the idea behind the proper formulation of our principle. Take any necessary truths that concern at most one fundamental first-order relation, whatever such necessary truths may be. Now take any plurality of first-order properties or relations which involves at least two fundamental determinably-distinct first-order relations. Then: for any way in which such properties or relations may be instantiating together that is compatible with such necessary truths, there is a metaphysically possible world where those properties or relations are instantiated that way. Here is how we may cash this out in terms of sentences of L. Let T be the set of all sentences of L with occurrences of *at most one* predicate expressing a fundamental first-order relation. A member of T may thus claim that *any* first-order properties or relations (whether

fundamental or not, whether pairwise determinably-distinct or not) are instantiated *any* way (either together or on their own), so long as it concerns no more than one fundamental first-order relation. Now let T^\square be the set of all members of T that are necessarily true, whatever such sentences may be. Then we may state our principle as the following recombination-to-possibility claim:

($R \Rightarrow P$)

For any predicates $\Pi_1^{i_1}, \dots, \Pi_n^{i_n}$ of L expressing fundamental, pairwise determinately-distinct first-order relations, and any formula $\phi(X_1^{i_1}, \dots, X_n^{i_n})$ of L , if $\{\phi(\Pi_1^{i_1}, \dots, \Pi_n^{i_n})\} \cup T^\square$ has a model, then there is a metaphysically possible world where $\phi(\Pi_1^{i_1}, \dots, \Pi_n^{i_n})$ is true,

where $n, i_j \geq 2$, to make it explicit that $R \Rightarrow P$ concerns only first-order relations and only ways in which two or more of them may be instantiated together. $R \Rightarrow P$ just says that any sentence of L with predicates for two or more fundamental determinably-distinct first-order relations is true at some possible world, provided that such sentence is compatible with all necessarily true sentences of L with at most one predicate expressing a fundamental relation, whatever such sentences may be. Such a sentence may claim that *any* first-order properties or relations (whether fundamental or not, whether pairwise determinably-distinct or not) are instantiated *any* way (either together or on their on), provided it concerns at least two fundamental determinably distinct first-order relations.

To get a better grip on $R \Rightarrow P$, think of T^\square as representing the set of whatever second-order properties each fundamental first-order relation may have essentially, whatever second-order properties each first-order property (whether fundamental

or not) may have essentially, whatever second-order relations may hold essentially among any first-order properties (whether fundamental and determinably-distinct or not), whatever second-order relations may hold among any first-order properties (whether fundamental or not) and any first-order relations (whether fundamental and determinably-distinct or not), and whatever second-order relations may hold among any non-fundamental and non-determinably-distinct first-order relations. $R \Rightarrow P$ claims that any second-order relation among any fundamental determinably-distinct first-order relations that is consistent with *all that is not* essential to them.

To further get clear on what $R \Rightarrow P$ says, it would be helpful to give two further equivalent formulations of it. Let's say that a sentence of L is a *candidate sentence* just in case it has occurrences of two or more predicates expressing fundamental determinably-distinct first-order relations. And let's say that a sentence of L is a *constraining sentence* just in case it has occurrences of no more than one predicate expressing a fundamental relation. Then we may reformulate $R \Rightarrow P$ as the claim that every candidate sentence that is compatible with any constraining sentences that are necessarily true—whatever such sentences may be—is true at some metaphysically possible world. We may also reformulate it as the claim that if every constraining sentence entailed by some candidate sentence is true at some metaphysically possible world, then so is that candidate sentence.

It is important to realize just how much weaker than (2-13) $R \Rightarrow P$ is: without assumptions about the contents of T^\square , $R \Rightarrow P$ has only trivial consequences. Suppose, for instance, that R_1 and R_2 are two fundamental, determinately-distinct, two-place first-order relations. (2-13) automatically delivers a world in which, for instance, something bears R_1 but not R_2 to itself. That is, (2-13) on its own entails that a sentence

of L according to which something bears R_1 but not R_2 to itself is true at some possible world. By contrast, $R \Rightarrow P$ alone delivers only trivial possibilities in which R_1 and R_2 are instantiated together— $R \Rightarrow P$ on its own does not entail that it is possible that something bear R_1 but not R_2 to itself. For R_1 may be essentially irreflexive, or R_2 may be essentially reflexive. That is, there may members of T^\square requiring that nothing bear R_1 to itself, or that everything bear R_2 to itself, which would be incompatible with any sentence of L according to which something bears R_1 but not R_2 to itself. So $R \Rightarrow P$ entails that it is possible that something bear R_1 but not R_2 to itself only given further assumptions about the essential second-order properties of R_1 and R_2 , *i.e.* that R_1 is not essentially irreflexive and that R_2 is not essentially reflexive. In other words, $R \Rightarrow P$ delivers a world where a sentence of L according to which something bears R_1 but not R_2 to itself is true only together with further assumptions about the contents of T^\square , *i.e.* that it has no members requiring that nothing bear R_1 to itself, or that everything bear R_2 to itself. Since making these assumptions about the contents of T^\square 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, this shows that $R \Rightarrow P$ delivers interesting possibilities only given *other* 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. But, on its own, $R \Rightarrow P$ is completely innocuous: since it is silent as to what is in T^\square , it alone entails only logical truths.⁷

Another example: let R_1 and R_2 be as above, and let F_1 and F_2 be two first-order properties. Even if we assume that it is possible that something bear R_1 to itself, and that it is possible that something not bear R_2 to itself, $R \Rightarrow P$ alone does not entail that it

⁷Of course, many actually true sentences of L are not logical truths, and any such sentence must be compatible with whatever the contents of T^\square may be. So $R \Rightarrow P$ does entail some non-trivial possibilities, *i.e.* those that are actual. So let me qualify my claim: other than actual contingencies, $R \Rightarrow P$ alone entails only logical truths; *i.e.* on its own, it delivers only trivial non-actual possibilities.

is possible that there be an F_1 that is not an F_2 , which bears R_1 to itself without bearing R_2 to itself. For T^\square may have a member according to which there is at least one F_2 , or according to which every F_1 is an F_2 , or according to which every F_1 does not bear R_1 to itself, or according to which every F_1 that is not an F_2 bears R_2 to itself, etc. So $R \Rightarrow P$ entails that it is possible that there be an F_1 that is not an F_2 and that bears R_1 but not R_2 to itself only given other possibilities, which rule out that T^\square have members like the above: *if* it is possible that there be an F_1 that is not an F_2 and that bears R_1 to itself, *and* it is possible that there be an F_1 that is not an F_2 and that does not bear R_2 to itself, *then* $R \Rightarrow P$ entails that it is possible that there be an F_1 that is not an F_2 and that bears R_1 but not R_2 to itself. By contrast, (2-13) does not need any further assumptions to deliver such possibility: it on its own entails that there is a world where there is an F_1 that is not an F_2 and that bears R_1 but not R_2 to itself.

Now, notice that $R \Rightarrow P$ is a Humean principle for determinably-distinct fundamental first-order relations, since it effectively requires that there be no necessary connections of a certain sort between them. But from the above it is clear that $R \Rightarrow P$ encodes only a very weak form of Humeanism: it denies only a very specific form of necessary connection among such relations. To illustrate the point, suppose again that R_1 and R_2 are two determinably-distinct fundamental first-order relations. $R \Rightarrow P$ allows for there to be necessary connections between R_1 and R_2 . For instance, it allows for them to be necessarily connected so that R_1 is transitive iff R_2 is reflexive. For as we have seen, $R \Rightarrow P$ is neutral as to what essential second-order properties R_1 and R_2 may have. And their having essential second-order properties requires that there be certain necessary connections between them. In this example, if R_1 is necessarily transitive and R_2 is necessarily reflexive, then it must be necessary that R_1 be transitive iff R_2 is reflexive. Similarly, $R \Rightarrow P$ allows for R_1 and R_2 to be necessarily connected

so that R_1 is instantiated iff so is R_2 . For as we have also seen, $R \Rightarrow P$ is neutral as to what necessary second-order relations R_1 and R_2 may bear to first-order properties and non-fundamental first-order relations. And R_1 and R_2 bearing certain second-order to first-order properties or non-fundamental first-order relations may require that there be certain necessary connections between them. In this example, if it is necessary that something bear R_1 to something only if it is F , and it is necessary that every F bears R_2 to something, then it must be necessary that something bear R_1 to something only if something bears R_2 to something. So although $R \Rightarrow P$ is a Humean principle for fundamental first-order relations that are determinably-distinct, the form of Humeanism at issue is very limited—it rules out only a very particular sort of necessary connection among the relations at stake. Moreover, from our discussion about second-order essentialism, it is not unprincipled to be a Humean about only certain sorts of necessary connections between them.

$R \Rightarrow P$ is then the recombination principle that will help deliver possibility of the cases of external deviations I am interested in. As should be clear from the above, we will need to make certain assumptions to get that result. I will introduce such assumptions in chapter 3, and show how exactly the possibility of the cases at stake from them and $R \Rightarrow P$. And I will also discuss what I take to be strong arguments for both $R \Rightarrow P$ and assumptions. What is important to keep in mind for the moment is what I have been trying to stress: that $R \Rightarrow P$ is a very precise, very weak, and yet perfectly general recombination principle—it applies to all entities satisfying a certain well-motivated condition and to all ways of recombining those entities that satisfy an also well-motivated condition.

2.7 Extending the Framework

The strategy by which I singled out $R \Rightarrow P$ is perfectly general—it allows for the systematization of recombination principles generally, not only for those concerning first-order properties and relations. I want to finish this chapter with some brief remarks about this.

The key idea I suggested for systematizing recombination principles concerning actual first-order properties and relations was to cash them out as claims according to which certain sentences of a sufficiently expressive language with predicates for certain of those properties and relations are possibly true. We may generalize this idea to systematize recombination principles concerning other sorts of entities. For instance, if you want to recombine not only actual but also merely possible first-order properties and relations, you need only extend L so that it includes predicates for such things. In that case, a principle, say, as strong as (2-12) would deliver not only a metaphysical possibility in which there are two apples that stand exactly two feet from one another, but also one in which there is an uncountable number of dragons and an uncountable number of unicorns such that every dragon stands less than Planck length from some unicorn.

Similarly, if you want to recombine not only properties and relations, but also particulars (whether only actual or also merely possible), you need just add individual constants to your language. In that case, a principle as strong as (2-12) would entail, for instance, not only that it is possible that *something* be nine feet tall, but also that it is possible that *Socrates* be nine feet tall. It would also entail not only that it is possible that *some human being* exist and the Earth have *satellites*, but also that it is possible that *Socrates* exist but *the Moon* does not.

Once you have individual constants and first-order predicates, you may also easily systematize recombination principles concerning states of affairs, entities made out of particulars instantiating properties. Suppose, for instance, that you want to recombine atomic states of affairs that are merely possible but that are made out of only actual particulars instantiating only actual first-order properties, *e.g.* the state of affairs of Socrates instantiating the property of being nine feet tall, the state of affairs of Wittgenstein instantiating the property of being four feet tall, etc. To get the relevant recombination principle, all you need is a language with individual constants for actual particulars and predicates for actual first-order properties. Then you may state the principle thus: for any atomic sentences of the language, if each of them is true at some possible world but not at the actual one, and their conjunction has a model, then there is a possible world at which such conjunction is true.

And so on for recombination principles dealing with different sorts of entities and different ways of recombining them. All you need is a sufficiently expressive language with expressions for the relevant entities. Then you may just formulate recombination principles for those entities as claims according to which such-and-such sentences of that language are true at some metaphysically possible world. This would give a precise rendition of many different sorts of principles, whether Humean or not, and would allow us to clearly see how exactly they are related to one another, *i.e.* whether one is weaker, stronger, equivalent, or independent of another. Of course, drawing distinctions between different such principles would have to be done on a case-by-case basis, as we did with recombination principles for actual first-order properties and relations. But the basic machinery to systematize such restrictions is perfectly general.

CHAPTER 3

THE POSSIBILITY OF EXTERNAL DEVIATIONS

My goal in this chapter is to show how exactly the metaphysical possibility of the cases of external deviations at issue follows from $R \Rightarrow P$ (the recombination principle singled out in chapter 2) and minimal assumptions about the nature of mereological relations and relations of spatiotemporal location. I will also defend $R \Rightarrow P$ and those assumptions in the qualified way that I described at the outset, and highlight a few general consequences of accepting the possibility of our cases of external deviations for various metaphysical debates.

3.1 Recombining Mereological and Location Relations

Remember from chapter 2 that the metaphysical possibility of our cases of external deviations follows from (2-13) and the assumptions that our primitive parthood relation, our primitive location relation, material thinghood, and regionhood are all fundamental and pairwise determinably distinct. Given that we have traded (3-13) for $R \Rightarrow P$, we may give up these assumptions for the following two, since $R \Rightarrow P$ recombines only first-order relations, not first-order properties:

(Fundamentality) Parthood and location are fundamental.

(Distinctness) Parthood and location are determinably-distinct.

That we need only assume fundamentality and determinable-distinctness for parthood and location is a significant advantage of $R \Rightarrow P$ over (3-13), for it is highly controversial whether material thinghood and regionhood are fundamental. But from

our discussion about just how weak $R \Rightarrow P$ is, it is clear that we also we need to take certain possibilities for granted. As we will see below, the following ones suffice for our purposes:

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

Assuming P1-P3 is the same as making certain assumptions about the contents of T^\square . Let 'M' be the predicate of L for material thinghood, 'R' the one for regionhood, ' \leq ' the one for our primitive parthood relation, '<' the one for the proper parthood relation defined in terms of our primitive parthood relation, '@_o' the one for our primitive location relation, and '@' the one for the exact location relation that we defined from our primitive one. Now remember that from the definition of proper parthood and exact location, ' $x < y$ ' abbreviates ' $x \leq y \ \& \ \neg y \leq x$ ' and that ' $x @ S$ ' abbreviates ' $\forall S'(x @_o S' \equiv \exists y (Ry \ \& \ y \leq S \ \& \ y \leq S'))$ '. Then it is clear that assuming P1-P3 is just to assume that each of the following sentences of L is true at some metaphysically possible world, *i.e.* that no sentence of L that is incompatible with any of them is a member of T^\square :

- (3-1) $\exists x_1 \exists x_2 \exists y_1 \exists y_2 (Mx_1 \ \& \ Mx_2 \ \& \ Ry_1 \ \& \ Ry_2 \ \& \ x_1 \neq x_2 \ \& \ y_1 \neq y_2 \ \& \ x_1 @ y_1 \ \& \ x_2 @ y_2)$

$$(3-2) \exists x_1 \exists x_2 \exists y_1 \exists y_2 (Mx_1 \& Mx_2 \& Ry_1 \& Ry_2 \& x_1 \leq x_2 \& \neg y_1 \leq y_2)$$

$$(3-3) \exists x_1 \exists x_2 \exists y_1 \exists y_2 (Mx_1 \& Mx_2 \& Ry_1 \& Ry_2 \& y_1 \leq y_2 \& \neg x_1 < x_2)$$

Let us now see how the metaphysical possibility of the cases of external deviations at stake follows from $R \Rightarrow P$, Fundamentality, Distinctness, and P1-P3.

First, $R \Rightarrow P$, Fundamentality, Distinctness, P1, and P2 entail that it is metaphysically possible that a material thing be part of a material object without being a contraction of that object, *i.e.* that violations of $\text{Parts} \Rightarrow \text{Contractions}$, and hence of $\text{Fusions} \Rightarrow \text{Expansions}$, are metaphysically possible. For consider a sentence, ϕ , of L according to which a material thing that is part of a material object is exactly located at a region that is not a subregion of that object's exact location. ϕ could then be any sentence of L equivalent to the following one:

$$(3-4) \exists x_1 \exists x_2 \exists y_1 \exists y_2 (Mx_1 \& Mx_2 \& Ry_1 \& Ry_2 \& x_1 @ y_1 \& x_2 @ y_2 \& x_1 \leq x_2 \& \neg y_1 \leq y_2)$$

Now notice that, by P1, no sentence of L concerning location, material thinghood, or regionhood that is inconsistent with ϕ is a member of T^\square . By P2, no sentence of L concerning parthood, material thinghood, or regionhood that is inconsistent with ϕ is a member of T^\square . So, by Fundamentality and Distinctness, the antecedent of $R \Rightarrow P$ is satisfied for ϕ . So $R \Rightarrow P$ requires that there be a metaphysically possible world where ϕ is true.

Another way to see this: given Fundamentality and Distinctness, $R \Rightarrow P$ is effectively a principle according to which if (3-1) is true at some metaphysically possible world, and so is (3-2), then so is (3-4). And P1 and P2 effectively tell us that there is a

metaphysically possible world at which (3-1) and (3-2) are true. So, from $R \Rightarrow P$, Fundamentality, Distinctness, P1, and P2 it follows that there is a metaphysically possible world at which (3-4) is true.

Second, $R \Rightarrow P$, Fundamentality, Distinctness, P1, and P3 entail that it is metaphysically possible that a material thing be a proper contraction of a material object without being a proper part of that object, *i.e.* that violations of Proper-Contractions \Rightarrow Proper-Parts, and hence of Contractions \Rightarrow Parts and Expansions \Rightarrow Fusions, are metaphysically possible. For consider a sentence, ϕ , of L according to which a material thing that is not a proper part of a material object is exactly located at a region that is a proper subregion of that object's exact location. ϕ could then be any sentence of L equivalent to the following one:

$$(3-5) \exists x_1 \exists x_2 \exists y_1 \exists y_2 (Mx_1 \ \& \ Mx_2 \ \& \ Ry_1 \ \& \ Ry_2 \ \& \ x_1 @ y_1 \ \& \ x_2 @ y_2 \ \& \ y_1 < y_2 \ \& \ \neg x_1 < x_2)$$

By P1, no sentence of L concerning location, material thinghood, or regionhood that is inconsistent with ϕ is a member of T^\square . By P3, no sentence of L concerning parthood, material thinghood, or regionhood that is inconsistent with ϕ is a member of T^\square . So, by Fundamentality and Distinctness, the antecedent of $R \Rightarrow P$ is satisfied for ϕ . So $R \Rightarrow P$ requires that it be true at some possible world.

From the alternative viewpoint: given Fundamentality and Distinctness, $R \Rightarrow P$ is effectively a principle according to which if (3-1) is true at some metaphysically possible world, and so is (3-3), then so is (3-5). And P1 and P3 effectively tell us that there is a metaphysically possible world at which (3-1) and (3-3) are true. So, from $R \Rightarrow P$, Fundamentality, Distinctness, P1, and P2 it follows that there is a metaphysically possible world at which (3-5) is true.

Thus, the metaphysical possibility of all the relevant violations of both directions of both Parts \Leftrightarrow Contractions and Fusions \Leftrightarrow Expansions follows from $R\Rightarrow P$, Fundamentality, Distinctness, and P1-P3. It is worth noting that by strengthening P2 and P3 just a tiny bit we may get cases of external deviations that are much more drastic than the ones we just got. For instance, consider:

(P2*) It is possible that there be a pair of material things, one of which is part of the other, and a pair of regions, which do not overlap.

(P2**) It is possible that there be a pair of material things, one of which is part of the other, and a pair of regions, one of which is a proper subregion of the other.

(P3*) It is possible that there be a pair of material things that do not overlap, and a pair of regions, one of which is a proper subregion of the other.

That is, suppose that the following sentences of L are true at some metaphysically possible world, *i.e.* that no sentence of L that is incompatible with any of them is a member of T^\square :

(3-2*) $\exists x_1 \exists x_2 \exists y_1 \exists y_2 (Mx_1 \ \& \ Mx_2 \ \& \ Ry_1 \ \& \ Ry_2 \ \& \ x_1 \leq x_2 \ \& \ \neg \exists y_3 (Ry_3 \ \& \ y_3 \leq y_1 \ \& \ y_3 \leq y_2))$

(3-2**) $\exists x_1 \exists x_2 \exists y_1 \exists y_2 (Mx_1 \ \& \ Mx_2 \ \& \ Ry_1 \ \& \ Ry_2 \ \& \ x_1 \leq x_2 \ \& \ y_1 < y_2)$

(3-3*) $\exists x_1 \exists x_2 \exists y_1 \exists y_2 (Mx_1 \ \& \ Mx_2 \ \& \ Ry_1 \ \& \ Ry_2 \ \& \ y_1 < y_2 \ \& \ \neg \exists x_3 (Mx_3 \ \& \ x_3 \leq x_1 \ \& \ x_3 \leq x_2))$

By the same reasoning above, $R\Rightarrow P$, Fundamentality, Distinctness, P1, and P2* entail that it is possible that a material thing be part of another, but that their exact locations

be completely disjoint. That is, they entail that some sentence of L equivalent to the following one is true at some possible world:

$$(3-4^*) \exists x_1 \exists x_2 \exists y_1 \exists y_2 (Mx_1 \ \& \ Mx_2 \ \& \ Ry_1 \ \& \ Ry_2 \ \& \ x_1 @ y_1 \ \& \ x_2 @ y_2 \ \& \ x_1 \leq x_2 \ \& \\ \neg \exists y_3 (Ry_3 \ \& \ y_3 \leq y_1 \ \& \ y_3 \leq y_2))$$

By the same token, if we replace P2* with P2**, 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 a material object, where that object's exact location is a proper subregion of that thing's exact location. That is, they entail that some sentence of L equivalent to the following one is true at some possible world:

$$(3-4^{**}) \exists x_1 \exists x_2 \exists y_1 \exists y_2 (Mx_1 \ \& \ Mx_2 \ \& \ Ry_1 \ \& \ Ry_2 \ \& \ x_1 @ y_1 \ \& \ x_2 @ y_2 \ \& \ x_1 \leq x_2 \ \& \\ y_2 < y_1)$$

These are two more specific and pretty extreme violations of Parts \Rightarrow Contractions, and hence of Fusions \Rightarrow Expansions. Similarly, R \Rightarrow P, Fundamentality, Distinctness, P1 and P3* entail that it is possible that a material thing that fails to altogether overlap some material object be a proper contraction of that object. That is, they entail that some sentence of L equivalent to the following one is true at some possible world:

$$(3-5^*) \exists x_1 \exists x_2 \exists y_1 \exists y_2 (Mx_1 \ \& \ Mx_2 \ \& \ Ry_1 \ \& \ Ry_2 \ \& \ x_1 @ y_1 \ \& \ x_2 @ y_2 \ \& \ y_2 < y_1 \ \& \\ \neg \exists x_3 (Ry_3 \ \& \ x_3 \leq x_1 \ \& \ x_3 \leq x_2))$$

This is a more specific and pretty extreme violation of Contractions \Rightarrow Parts, and hence of Expansions \Rightarrow Fusions.

$R \Rightarrow P$, Fundamentality, Distinctness, P1, and the different versions of P2 and P3 are thus strong enough to give us very radical cases of external deviations. The question now is, of course, whether these claims are in fact true. Below I will defend these claims. First, I will show that they have none of the questionable consequences that (3-13) and the other assumptions have, and that they are in fact collectively very weak. Then I will go through $R \Rightarrow P$, Fundamentality, Distinctness, and P1-P3 one by one, and argue that rejecting each of them requires very extreme views, perhaps more so than accepting the possibility of our cases of external deviations.

3.2 No Unexpected Costs

Let us then see why $R \Rightarrow P$, Fundamentality, Distinctness, P1, and the different versions of P2 and P3 are weak enough to deliver none of the other controversial and implausible consequences of (3-13) et al. This should be clear from the fact that (i) without further assumptions, $R \Rightarrow P$, Fundamentality, and Distinctness entail only trivial possibilities; that (ii) P1 makes very few demands about location, material thinghood, and regionhood, whether taken together or on their own; and that (iii) the different versions of P2 and P3 make very few demands about parthood, material thinghood, and regionhood, whether taken together or on their own. For instance, P1 and the different versions of P2 or P3 are compatible and with parthood being necessarily reflexive, as well as with it being necessarily transitive; *i.e.* they do not require that T^{\square} have no members according to which parthood is reflexive, or according to which it is transitive. So they are compatible with the antecedent of $R \Rightarrow P$ being unsatisfied for every sentence of L according to which parthood is not reflexive, or according to which it is not transitive. Similarly, P1 and the different versions of P2 and P3 are

compatible with parthood being necessarily governed by classical extensional mereology in both the case of material objects and the case of regions, with gunky 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 or regions, with it being impossible that a material object be located nowhere, etc. It is clear that T^\square may contain sentences of L for all the corresponding necessities.

Notice that from this it follows that all the above cases of external deviations are *themselves* neutral on all the controversial consequences of (3-13) et al. So all such cases are compatible with very strong necessities involving location, material thinghood, and regionhood, as well as with very strong necessities involving parthood, material thinghood, and regionhood. It will be useful to go through a couple of cases where this may not be obvious. First, Expansions \Rightarrow Fusions 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 exact location with y , there need not be co-located material objects in this situation. Second, Proper-Contractions \Rightarrow Proper-Parts 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 of a material thing, y , but that x is not proper part of y . That is compatible with y having proper parts, and even with y being gunky; all that is 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 exact 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, and the different versions of P2 and P3 entail that the mereological structures of the material world and spacetime may radically misalign, 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 internally misalign: $R \Rightarrow P$, Fundamentality, and Distinctness deliver the possibility of internal deviations only if P1-P3 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 is worth noting that all the above cases of external deviations are also compatible with very strong claims of a different sort. Consider, for instance, universalism about expansions (*i.e.* the claim that any material things have an expansion), uniqueness about expansions (*i.e.* 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-P3 require that none of such claims be necessary, since they are claims according to which parthood and location are instantiated together in some way. But it is interesting that there may be worlds with external deviations where such claims hold, for it stresses just how little external deviations require. For instance, $\text{Fusions} \Rightarrow \text{Expansions}$ may be violated at worlds where expansions are 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 expansions 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 exact location is not z 's exact location.) Similarly, Parts \Rightarrow Contractions 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 exact location is not the location of any of y 's contractions.)

Here is another way in which $R\Rightarrow P$, Fundamentality, Distinctness, P1, and the different versions of P2 and P3 are very weak. These claims are neutral as to which first-order properties and relations particulars have or stand in essentially, *i.e.* on issues about first-order essentialism. For instance, they do not entail that it is possible that my hand be one of my parts but not one of my contractions, or that it is possible that my head be one of my contractions but not one of my parts. Nor do they entail that I could have a part that is not one of my contractions, or a contraction that is not part of me. Moreover, they are compatible with such strong views as mereological essentialism (the view that a thing's parts are essential to it) and locational essentialism (the view that a thing's locations are essential to it). All this is clear from the fact that no sentence of L has individual constants: $R\Rightarrow P$, Fundamentality, Distinctness, P1, and the different versions of P2 and P3 deliver only *de dicto* possibilities.

3.3 A Reductio?

So far I have argued that the possibility of violations of both directions of both Parts \Leftrightarrow Contractions and Fusions \Leftrightarrow Expansions follows from $R\Rightarrow P$, Fundamentality, Distinctness, and P1-P3. But all this means is that these claims together are inconsistent. So one may take this result as a reductio on at least one of $R\Rightarrow P$, Fundamentality, Distinctness, and P1-P3, rather than as an argument for the possibility of external deviations. As I mentioned at the outset, I will remain neutral on this issue. I will only argue that rejecting $R\Rightarrow P$, Fundamentality, Distinctness, or P1-P3 leaves us with a choice of equally unappealing alternatives. 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-P3. 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 exactly located. That is, all it claims is that there is a metaphysically possible world at which (3-1) is true. So rejecting this claim seems pretty extreme: one would have to hold that it is impossible that there be at least two regions, or that it is impossible that there be at least two material objects, or that it is impossible that a material object be exactly 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 (cf. Hawthorne and Cortens 1995). One may reject P1 by arguing that existence nihilism is necessarily true, for such view entails that it is impossible that there be any material objects or regions. Or consider existence monism, the view that there is exactly one concrete object (cf. Horgan and Potrč 2000). One may reject P1 by arguing that existence

monism is necessarily true, for such view entails that it is impossible that there be at least two material objects, or at least two regions. But thinking that either existence nihilism or existence monism is necessarily true is arguably at least as radical as thinking that external deviations are possible.

It is worth noting that other seemingly less drastic views are not on their own sufficient to reject P1. For instance, P1 is compatible with the bundle theory of particulars being necessarily true. For the bundle theory does not claim that there are no regions or 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. Similarly, the view that substantivalism about spacetime is necessarily false does not suffice to reject P1. For, as I argued at the outset, substantivalists and relationalists disagree about the *nature* of spacetime, not about its *existence*, and P1 is neutral as to what the nature of spacetime may be. In other words, P1 is perfectly compatible with any views you might have as to whether the existence and features of regions is reducible to 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. Remember that supersubstantivalism is the view that every material thing is identical to its exact 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 neutral as to what the nature of material things may be. (Supersubstantivalism *does* provide a way of resisting the possibility of external deviations, which I address below. My point here is only that the necessary truth of supersubstantivalism does not require that P1 be false.)

Another way to put the point: the necessary truth of the bundle theory, relationalism, or supersubstantialism does not guarantee the existence of members of T^\square that are incompatible with a sentence of L according to which two material objects are exactly located at two regions. The existence of such members of T^\square follows only from more radical nihilist claims about the existence of material things and regions. It seems, then, that any reasonable way to reject P1 along these lines requires that a view along the lines of existence nihilism or existence monism be necessarily true.

I want to finish my discussion of P1 by noting why a less extreme way in which P1 may be rejected is ultimately ineffective. One may think that although it is necessary that every material object be *located* somewhere, it is not necessary that every material object be *exactly located* at some region. That is, one may reject an assumption I made at the outset: that exact location is necessarily a total function on material things. This in fact seems to be actually the case: quantum mechanics suggests that the exact location of some fundamental particles is indeterminate.

However, this on its own is not sufficient to reject P1, for P1 only claims that it is *possible* that some material thing be exactly located somewhere. What is required in order to reject P1 along these lines is that it be altogether impossible that a material object have an exact location. This would seem to be a pretty extreme view, perhaps more so than any of the ones considered so far. But even if such view is true, we may still get misalignments of the intended sort by focusing on *entire* location, or even *weak* location instead of on exact location. Consider, for instance, a weakening of P1 along the following lines: it is possible that there be two material things and two regions, such that one material thing is entirely/weakly located one region but not at the other, and the other material thing is entirely/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 is possible that a thing be part of another, but that it be entirely/weakly located at a region that the other is not. So in order to reject this weakening of P1 along the intended lines, a yet more exotic view is required: that it is impossible that a material object be entirely/weakly located somewhere!

Thus, rejecting P1 leaves us with a choice of alternatives that are at least as radical as the possibility external deviations. Let me now move on to P2 and P3.

P2 and P3 are also very weak: all they claim is that (3-2) and (3-3) are true at some possible world. Like with P1, these claims may be rejected by arguing that a view such as that existence nihilism or existence monism is necessarily true. 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. One may then reject P2 and P3 by arguing that mereological nihilism about both material objects and regions is necessarily true, *i.e.* that only simple material objects and regions are possible. But this view is also a very extreme one: it claims that both composite material objects and composite regions are impossible. So it seems that rejecting P2 and P3 also leaves us with a choice of no less radical alternatives than the possibility of external deviations.

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

As discussed in chapter 2, 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. But $R \Rightarrow P$ cannot be dismissed on either of these

grounds. Unlike principles along the lines of (3-9), it is perfectly precise: its logical form is transparent, and it is absolutely clear what exactly follows from it. And unlike principles such as (3-11)-(3-13), it does not entail too much. In fact, remember that $R \Rightarrow P$ is very weak: it alone delivers only trivial possibilities.

Given how weak $R \Rightarrow P$ is, it is a very hard claim to reject. It may be rejected only if there is a plurality of fundamental, pairwise determinably-distinct first-order relations other than parthood and location, such that there are independently plausible possibilities concerning only one of those relations (*i.e.* possibilities playing the role of P1-P3) on the basis of which $R \Rightarrow P$ delivers an independently implausible possibility concerning two or more of those relations (*i.e.* a possibility playing the role of the possibility of external deviations). For only by there being one such plurality of relations would one have independent motivation to reject $R \Rightarrow P$.

It is hard to think of one such an independently motivated case against $R \Rightarrow P$. Moreover, one may give a direct argument for $R \Rightarrow P$, which rules out the existence of such counterexamples. Here is the gist: arguably the contents of T^\square allow that $R \Rightarrow P$ be true of at least some fundamental determinably-distinct first-order relations and at least some non-trivial non-actual ways of instantiating them together. That is, arguably the contents of T^\square 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^\square). 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 fundamental determinably-distinct first-order relations and any non-trivial non-actual ways of instantiating them together that are compatible with T^\square , 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*.

In order to resist the argument from metaphysical parity one must either buy into arbitrariness or deny that $R \Rightarrow P$ is true of at least some fundamental determinably-distinct first-order relations and at least some non-trivial non-actual ways of instantiating them together. The former option is unacceptable—nature does not play favorites. But the latter one is not 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 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 various fundamental determinably-distinct first-order 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 κ concrete things, for some cardinal number κ . But if such sentences are necessarily true, then it is impossible that there be fewer than κ concrete things. This is problematic not only because that there are at least κ 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 unpalatable options: either metaphysical arbitrariness or that seemingly contingent features of the actual world are not only necessary, but also brutally necessary.

Let me now turn to Fundamentality. Remember that to say that parthood and location are fundamental is to say that facts about each are not grounded on facts about some other first-order properties or relations. So in order to reject that parthood is fundamental it is not sufficient to argue that parthood may be defined in terms of other mereological relations, such as proper parthood, overlap, etc. For that at best shows that parthood is not *theoretically* or *conceptually* primitive, not that it is not *metaphysically* primitive. Moreover, what is at stake is whether facts about mereological relations are grounded on facts about some non-mereological properties or relations. This is completely independent of which mereological relation one takes to be conceptually prior, as well as of whether Fundamentality is formulated in terms of parthood or in terms of other mereological relations. Similarly, in order to reject that location is fundamental it is not enough to note that location may be defined in terms of other location relations. Again, what is at stake is whether facts about location relations are grounded on facts about some non-locational properties or relations. And this again is completely independent of which location relation one takes to be conceptually primitive, as well as of which such relation Fundamentality is formulated in terms of.

In order to reject Fundamentality it is not sufficient to think that facts about the location of composite material objects are grounded on facts about the location of their parts either (cf. Brzozowski 2008, Williams 2008). This is a picture on which 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. But then there is still a fundamental location relation on this view, and this is all Fundamentality requires. Moreover, violations of $\text{Contractions} \Rightarrow \text{Parts}$ need only involve location of simple material things: that x is a contraction but not a part of y is compatible with both x and y being simple. But the more serious problem with this attempt at undermining Fundamentality is that the view in question is perfectly compatible with violations of either direction of either $\text{Parts} \Leftrightarrow \text{Contractions}$ or $\text{Fusions} \Leftrightarrow \text{Expansions}$. For instance, pace Brzozowski and Williams, that x is a part but not a contraction of y is perfectly compatible with the claim that y is located where it is in virtue of x and the rest of y 's proper parts being located where they are.

Now, it is hard to see which facts about non-mereological properties or relations could ground facts about mereological relations. It is also hard to see which facts about some non-locational properties and relations could ground facts about locational relations. But not only is it difficult to see how could Fundamentality be rejected—there is also a general worry about rejecting it. The worry is that doing so would effectively undermine *every* 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 have been offered for the possibility of cases of internal deviations, such as the possibility of mereological simples with a mereologically complex exact location. Such arguments require Fundamentality as a premise, for as we have seen there are independent reasons not to want to recombine non-fundamental first-order relations. So if one thinks that it is possible that there be internal deviations but not external ones, then a new kind of argument is needed for the possibility

of internal deviations, which does not have Fundamentality as a premise and does not generalize for the possibility of external deviations. Moreover, a new kind of *explanation* for why internal deviations are possible is called for: we can no longer say that they are possible because such-and-such components of reality may be recombined in such-and-such way. Brute modality threatens once again.

Of course, if it is necessary that the mereological structures of the material world and spacetime perfectly align, then it will not be a problem that rejecting Fundamentality undermines every combinatorial argument for the possibility of any sort of misalignment between those structures, as well as every combinatorial explanation of any such possibility. But brute modality threatens here as well: an explanation of such necessity is called for. And it seems that the only view capable of fully explaining why such perfect alignment is necessary is the view that supersubstantivalism is necessarily true. If supersubstantivalism is necessarily true, then it is trivial that both internal and external deviations are impossible. If every material thing *is* its exact location, then, trivially, its mereological structure and that of its exact location perfectly align. And if material things *are* their exact locations, then mereological relations on them and on their exact locations are trivially preserved in both directions. The necessary truth of supersubstantivalism would thus fully and easily explain the necessity at issue. (Schaffer MSb defends supersubstantivalism precisely on these grounds.) But the view that supersubstantivalism is necessarily true is arguably at least as radical as the view that external deviations are possible.

So not only is it hard to see what non-mereological and non-locational facts could ground mereological and locational facts: rejecting Fundamentality also leaves us with either brute modality or the view that supersubstantivalism is necessarily true. And both options are at least as unpalatable as the possibility of external deviations.

Let's now go onto Distinctness. This would seem to be an uncontroversial claim: it seems that neither parthood nor location is a determinate of the other, and that they are not determinates of some common determinable (other than a trivial one: relationship). However, Distinctness may be rejected under supersubstantivalism. For if every material object is identical to its exact location, then for a material thing to be located at some region is for it to *overlap* that region. So, according to supersubstantivalists, 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 actually explains why for the supersubstantivalist it is trivial that both internal and external deviations 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 will be a *logical falsehood*. 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 a thing that is part of another without being part of it.

I have already said that I believe that supersubstantivalism is as radical as that external deviations are possible. And it is hard to think of any other grounds on which one may reject Distinctness. So it seems that rejecting it leaves us again with a choice of equally unappealing alternatives.

To conclude this section, I would like to discuss a final way in which one may block the argument for the possibility of external deviations, which targets a couple of background assumptions, rather than $R \Rightarrow P$, Fundamentality, Distinctness, and P1-P3. Remember that at the outset we assumed that there was only one sort of part-whole relations, so that if any things stand in some part-whole relation to one another, then such relation must be definable in terms of the parthood relation we chose as primitive. Similarly, we assumed that there was only one sort of relations of spatiotemporal location, so that if any things stand in some location to some regions, then such relation must be definable in terms of the location relation we chose as primitive. Call the views that reject these assumptions *mereological pluralism* and *location pluralism*, respectively. According to the former, there is more than one primitive sort of mereological relations, which are not interdefinable; according to the latter, there is more than one sort of location relations, which are not interdefinable. Each of these views affords a way to resist the argument for the possibility of external deviations. For instance, mereological pluralism allows for there to be a sort of part-whole relations that hold exclusively among material things, and another sort that hold exclusively among spacetime regions. But then such relations will fail to be determinably-distinct—they are both part-whole relations of some sort or other—and hence they will not be amenable to recombination. Similarly, location pluralism would allow, for instance, for a view on which every material object bears a different sort of location relation to spacetime regions. But if so, location relations will not be able to be recombined with mereological relations so that there are external deviations.

Regardless of what one may think about the viability of pluralist proposals along these lines, blocking the argument for external deviations this way will face the same general worries that rejecting Fundamentality faces. Adopting any such proposal

would undermine any combinatorial argument for and explanation of the possibility of any sort of misalignment between the part-whole structure of the material world and the part-whole structure of spacetime. And if so, on pain of brute modality, one would once again have to resort to thinking that supersubstantivalism is necessarily true.

Rejecting, then, one of $R \Rightarrow P$, Fundamentality, Distinctness, and P1-P3 leaves us with a choice of alternatives that are just as unpalatable as the possibility of external deviations: that existence nihilism is necessarily true, that existence monism is necessarily true, that mereological nihilism about both material objects and regions is necessarily true, that supersubstantivalism is necessarily true, that there is metaphysical arbitrariness, and that some possibilities and necessities are brute. Another way to put the point: anyone who thinks that neither existence nihilism nor existence monism is necessarily true, that supersubstantivalism is not necessarily true, that there is no metaphysical arbitrariness, and that there are no brute modal facts must believe that external deviations are metaphysically possible. So this result should be of great interest, for very few philosophers are existence nihilists, existence monists, supersubstantivalists, or friends of either arbitrariness or brute modality.

As I mentioned above, I will not further discuss whether any of the alternatives is to be preferred over the possibility of external deviations. Instead, I now want to highlight a few ways in which their possibility is relevant to various other important debates in metaphysics, for that their possibility may be weighed against other sorts of considerations perhaps illuminates whether we should accept or reject them. In the remainder of this chapter I will discuss the relevance of their possibility for a few debates very generally. In the remaining two chapters I will delve deeply into two more specific consequences.

3.4 So What if They Are Possible?

Remember that external deviations are those in which mereological relations fail to be preserved either from some material things to their exact locations, or from some material things' exact locations to those material things. One way to conceive of external deviations is as misalignments between the mereological structure of the material world and the mereological structure of spacetime. But one may also conceive of them as failures of correspondence between two structures of the material world: its mereological structure, which is fixed by the part-whole relations that material things bear to one another, and its spatiotemporal structure, which is fixed by the relations of relative spatiotemporal location that material things bear to one another. For remember that cases violating either direction of either $\text{Parts} \Leftrightarrow \text{Contractions}$ or $\text{Fusions} \Leftrightarrow \text{Expansions}$ are just cases in which mereological relations and relations of relative spatiotemporal location among material objects come apart in one or the other direction. Conceiving of external deviations in this second way will allow us to more directly see how their possibility has a strong bearing on various important debates in metaphysics.

Although cases of external deviations require that the mereological and spatiotemporal structures of the material world misalign, they are compatible with those structures being equally *complex*. For remember from §3.2 above that $\text{Expansions} \Rightarrow \text{Fusions}$ may be violated even if composition among material objects is unrestricted: 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, $\text{Fusions} \Rightarrow \text{Expansions}$ may be violated even if expansion among material objects is unrestricted: y may be a fusion but not an ex-

pansion of the x s even if any things—including the x s, as well as the x s and y —have an expansion. From this it is easy to see that either direction of Fusions \Leftrightarrow Expansions may be violated even if *both* composition and expansion are unrestricted, for nothing in these situations would prevent any material things from having both a fusion and an expansion. So it is clear that we may have external deviations, and hence misalignments between the mereological and spatiotemporal structures of the material world, even if those structures are equally complex.

However, some of the most interesting consequences of the possibility of external deviations involve cases where the mereological and spatiotemporal structures of the material world *differ* in complexity. To see this, let's first see how there may be such differences. Notice that just as Expansions \Rightarrow Fusions may be violated even if composition among material objects is unrestricted, it may be violated even if mereological nihilism about material objects is true: 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. But from this it follows that a world may have spatiotemporally complex material objects without having mereologically complex ones, *i.e.* that a world may have material objects with proper contractions but no material objects with proper parts. So the material world may be *spatiotemporally complex* but *mereologically simple*. Similarly, just as Fusions \Rightarrow Expansions may be violated even if expansion is unrestricted, it may be violated even if nihilism about expansions is true: 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. It follows that a world may have mereologically complex material objects without having spatiotemporally complex ones, *i.e.* that a world may have material things with

parts but no material things with proper contractions. The material world may thus be *mereologically complex* but *spatiotemporally simple*.¹

Of course, the complexity of the mereological and spatiotemporal structures of the material world may come apart in other ways. For there are three general views about composition among material objects: that it is unrestricted (any material things compose something), that it is restricted (only some material things compose something), and that it is null (no two or more material things compose something). And there are three analogous views about expansion among material objects: that it is unrestricted (any material things expand into something), that it is restricted (only some material things expand into something), and that it is null (no two or more material things expand into something). From the above it is easy to see that each of these views on composition is compatible with each of these views about expansion. So the mereological and spatiotemporal complexity of the material world may differ in any of these ways.

Let's then go into some consequences of the possibility of external deviations in which the mereological and spatiotemporal structures of the material world differ in complexity. Consider a world where $\text{Expansions} \Rightarrow \text{Fusions}$ is violated but where mereological nihilism about material objects holds. Such a world would be populated by material objects of an interesting sort, which I call *crowded* extended simples. Crowded extended simples are mereologically simple but spatiotemporally complex material objects, *i.e.* they have proper contractions but no proper parts. Crowded extended simples may then be arbitrarily large, since they may have arbitrarily large

¹Remember that $R \Rightarrow P$, Fundamentality, Distinctness, and P1-P3 are neutral on what the mereological structure of both the material world and spacetime look like. So they are also neutral on whether it is metaphysically possible that the mereological and spatiotemporal structures of the material world differ in complexity. To explore the relevance of external deviations for other debates in metaphysics, I am bracketing these issues.

contractions. They may also have arbitrary spatiotemporal complexity, since they may have an arbitrarily large number of contractions. Provided that the mereological structure of their exact location allows for it, each of their contractions may even have proper contractions, *i.e.* they may be *spatiotemporally gunky*. Moreover, their exact location may be a scattered region. But they would still be mereologically simple: they would have no proper parts.

The possibility of crowded extended simples has not been entertained in the literature before. In fact, it has been widely assumed that a simple may have no proper contractions. Sider (2007), for instance, claims that no material thing could be exactly located at a proper subregion of an extended simple's exact location, hence implicitly assuming that crowded extended simples are impossible. Certain views on simples allow for material *stuff* to be exactly located at proper subregions of an extended simple's exact location (*e.g.* Markosian 1998, 2004). But crowded extended simples have material *things*, not material stuff, within their exact 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 mereological nihilists need not be committed to believing that only tiny, structureless material objects exist, as it is commonly thought. In fact, it shows that mereological nihilists may believe in a multitude of arbitrarily large material objects with an arbitrarily complex structure. This suggests that a mereologically nihilist ontology allows for 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.²

²Of course, it is not obvious how such an ontology may avoid the metaphysical problems that motivate mereological nihilism in the first place (*e.g.* puzzles about coincidence and change about common sense material things). In a work in progress, I show how this may be done.

Crowded extended simples also have a strong bearing on debates about how material things extend and change across space and time. First, crowded extended simples extend across space and time without having spatial or temporal parts. Let's say that a material thing extends over space iff it spreads over more than one spatial region, and persists over time if it spreads over more than one time. Let's also say that *perduring* objects are those that extend over space without having spatial parts, and that *perduring* objects are those that persist over time by having temporal parts. Cf. Parsons (MS). Then it is clear that crowded extended simples they do not extend over space by *perduring*, and they do not persist over time by *perduring*, for they have no proper parts. Nonetheless, crowded extended 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 extended simples, there may be a material object exactly located at that region (compare with Hawthorne 2006). Moreover, there may be *exactly one* material object at any such region, and so there may be plenitude in a non-*perduring* and non-*perduring* world even without coincident material objects.

Second, crowded extended 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. Notice that this is perfectly compatible with F and G being properties that material things have *simpliciter*. Crowded extended simples thus show that material things with neither spatial nor temporal parts may vary across space and time without having properties relative to spatial or temporal regions (as well as without having anything so fancy as distributional properties; cf. 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 me now discuss a few consequences of another way in which the complexity of the mereological and spatiotemporal structures of the material world may come apart. Consider a world where $\text{Fusions} \Rightarrow \text{Expansions}$ is violated but where nihilism about expansions holds. Such a world would be inhabited by material objects of another interesting sort, which I call *compact fusions*. Compact fusions have proper parts but no proper contractions: they are spatiotemporally simple but mereologically complex material things. Compact fusions may thus be arbitrarily small. Provided that the mereological structure of spacetime allows for it, their exact location may even be a simple region, *e.g.* a point. 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 may be, the possibility of compact fusions is connected to various debates in metaphysics.³ For instance, it goes against various sufficient conditions for mereological simplicity that have been given 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 mereologically simple if it, and only it, is exactly located at some point.⁴ But from the above it

³That a material thing has proper parts that are not contractions of it may not be as outlandish a claim as one may think. Two kinds of cases to consider: first, Sider reminds us 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, §2). A view on mereological relations on which claims along these lines (even if not the specific ones Sider mentions) are literally true would have room for compact fusions. And it seems that one such view should not be dismissed without argument—perhaps it gets at what is deep, intimate, and special about parthood. Second, consider quantum nonlocality. Perhaps action at a distance involves mereologically related but spatially disjoint material objects.

⁴A maximally continuous object is a material thing that is exactly 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.

is clear that a compact fusion may be maximally continuous and exactly 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 part-hood. For clearly a compact fusion must fail to be located at some 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 my nose and the Eiffel tower it does not follow that there is an object that is located at both Paris and New York.

Perhaps crowded extended simples and compact fusions reveal something more general about metaphysical debates concerning the structure of the material world, however. 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 issues 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 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 the questions about parts and fusions have been addressed in the literature, *i.e.* that debates over contractions and expansions would simply follow the 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 exact location). On the other hand, we have seen that $R \Rightarrow P$, Fundamentality, Distinctness, and P1-P3 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-P3 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.

Let me close this chapter with another debate for which the possibility of external deviations is relevant: the debate over coincident material objects. Consider the old puzzle of a statue and the lump of clay it is made of. There is a view on which the lump and the statue are both composed of some plurality of physical particles, but on which 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 deviations makes it clear otherwise, however, provided we think—as friends of distinct coincident objects do—that uniqueness of composition, expansion, and exact 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 deviations show that this view is coherent—it also show how the statue and the lump may differ in their categorical features: they differ in their *parts*. So external deviations also afford new treatment of the grounding problem for coincident objects.

CHAPTER 4
PERSISTENCE, DIACHRONIC COMPOSITION, AND DIACHRONIC
CONTRACTION

Perdurantism is the view that things persist over time by having different temporal parts at different times at which they exist. One of the most interesting and influential arguments for this view is the so-called *argument from vagueness*, the clearest and most compelling formulation of which we owe to Sider (1997, 2001). The general structure of the argument is straightforward. It has two main steps. The first step aims at establishing unrestricted diachronic composition—the view that for any things and any times at which they exist, there exists an object that those things compose across those times—from considerations about indeterminacy. The second step purports to show that perdurantism follows from unrestricted diachronic composition.

Filling in the details gets a bit more complicated. For the first step, the idea is to apply Lewis's argument for unrestricted composition *simpliciter*—the view that any things whatsoever compose something—to the cross-temporal case. Here is the gist of Lewis's argument: any plausible restriction on composition requires that composition be indeterminate. Composition cannot be indeterminate; so, there is no restriction on composition (Lewis 1986, pp. 212-213). The thought is to apply this to the cross-temporal case as follows: any plausible restriction on diachronic composition requires that it be indeterminate. Diachronic composition cannot be indeterminate; so, there is no restriction on diachronic composition. For the second step, the idea is that unrestricted diachronic composition entails that a thing exists at some time only if it has a temporal part at that time. And this consequence is supposed to be tantamount to accepting perdurantism.

Objections to the first step of the argument have focused on the plausibility of restrictions on composition that do not require that (diachronic) composition be indeterminate, as well as on the question of whether (diachronic) composition may be indeterminate (see next chapter). Objections to the second step have focused on the jump from unrestricted diachronic composition to perdurantism (Koslicki 2003, Miller 2005, Lowe 2005; see Varzi 2007 for discussion). Here I would like to press on a different sort of worry. The worry is that the argument does not distinguish between mereological relations and relations of relative spatiotemporal location. As a result, the argument requires not the view that diachronic composition is unrestricted, but a much stronger view, which effectively claims not only that composition across time is unrestricted, but also that contraction across time is unrestricted. However, in light of the distinction between fusions and expansions and between parts and contractions, this is something that foes of perdurantism may have independent motivation to reject. My aim in this chapter is to articulate this worry: I will argue that the distinction between matters of mereology and matters of relative spatiotemporal location affords a new way of resisting the argument from vagueness for perdurantism.

I will spell this out in two stages. First, I will present the argument from vagueness for perdurantism in a bit more detail. Second, I will explain how the argument runs together matters of mereology and matters of relative spatiotemporal location, as well as how distinguishing between them undermines the argument.

4.1 The Argument from Vagueness for Temporal Parts

The aim of the argument from vagueness is to establish perdurantism. Roughly, perdurantism is the view that things exist at different times by having different temporal

parts at each of those times, where a temporal part of an object at some time is a “slice” of such an object at that time.

The notion of existence at a time at play here is none other than the familiar notion of location at a region of spacetime we have been working with so far: to say that a thing, x , exists at a time, t , is just to say that x is located at t . If t is an instant, then to say that x is located at t is to say that x is located at some region of spacetime that has t as its temporal coordinate. And if t is a non-instantaneous interval (whether continuous or scattered), then to say that x is located at t is to say that x is located at a spacetime region that has subregions in common with some spacetime region that has some instant within t as its temporal coordinate. For simplicity’s sake, in what follows I will stick to talk about things bearing location relations to times instead of regions of spacetime. But this talk is technically to be understood as things bearing location relations to regions of spacetime in the way I just specified.

Now, how to characterize perdurantism and temporal parts in a precise way is a matter of some controversy (see Parsons 2007 for discussion). For simplicity’s sake, here I will not go into those issues, and will concentrate on a formulation of perdurantism and a definition of temporal parts that are very close to Sider’s own. The characterizations I will use are as follows:

(Perdurantism)

For any material object, x , and any time, y , x is pervasively located at some time, t , only if x has a temporal part at t ;

(Temporal Parts)

For any pair of material things, x and y , and any time, t , x is a temporal part of y at $t =_{df}$ x is part of y at t , x exactly located at t , and x overlaps at t every part of y at t ;

A couple of points are worth noting. First, like Sider's own characterizations, the ones above take mereological relations to be temporally relativized. This departs from my understanding of parthood so far as an unrelativized relation, but it will not make a difference in my argument.¹ Second, Perdurantism is to be understood as quantifying over any time whatsoever, no matter how long or how scattered. Similarly, the notion of a temporal part is defined for any such time.² This allows us to have a unified formulation of perdurantism and temporal parts for instants and intervals, unlike for Sider, who treats instants and intervals separately (2001, pp. 59-60).

To illustrate what perdurantism claims, consider my nose, which existed from Monday through Wednesday this week (it existed before that and has existed after that, but let's concentrate only on that interval). By the definition of pervasive location (see chapter 1), my nose is pervasively located at all of the following times: Monday, Tuesday, Wednesday, the interval from Monday to Tuesday, the interval from Tuesday to Wednesday, the interval from Monday to Wednesday, and the scattered interval made out of only Monday and Wednesday. Perdurantism requires that for each such time, my nose have a temporal part then, *i.e.* that there be a thing that is part of my nose at that time, that overlaps at that time every part of my nose then,

¹Taking parthood at a time as undefined, we may define other temporally relativized mereological relations as follows: x is proper part of y at $t =_{df}$ x is part of y at t , and y is not part of x at t ; x overlaps y at $t =_{df}$ something is part of both x and y at t ; some x s compose y at $t =_{df}$ each of those x s is part of y at t , and every part of y at t overlaps at t at least one of those x s.

²If t is an interval, then x is part of y at t iff x is part of y at every time in t . Similarly, x overlaps y at t iff x overlaps y at every time in t .

and that is exactly located then. And so on for any other time at which my nose is pervasively located.

With these characterizations of perdurantism and temporal parts in mind, let's move on to the argument from vagueness. The argument aims to establish Perdurantism on the grounds that diachronic composition is unrestricted. What exactly is diachronic composition, though? Given temporally relativized parthood, the notion of synchronic composition, *i.e.* of some things composing another *at a time*, is clear. But characterizing composition *across time* is less straightforward. One idea is as follows. Suppose that t_1 and t_2 are two times, and that the x s and the y s are two pluralities of things such that each of the x s is pervasively located at t_1 , and each of the y s is pervasively located at t_2 . Then an object composed of those things across those times is a thing that is composed of the x s at t_1 , and of the y s at t_2 . Sider builds on this idea, and generalizes it with the notions of an *assignment* and of a *D-fusion* (short for *diachronic fusion*) (2001, p. 133). An assignment, f , is a function from times to classes of objects such that every member of $f(t)$ is pervasively located at t . An object is a D-fusion of an assignment f iff for every t in f 's domain, such an object is composed at t of the members of $f(t)$. Sider also introduces a stronger notion, which is key for the argument from vagueness, *i.e.* the notion of a *minimal* D-fusion. A minimal D-fusion of an assignment f is a D-fusion of f that is exactly located at interval made up from the times in f 's domain.

Now, call the view that every assignment has a minimal D-fusion *universalism about minimal D-fusions*, or (U) for short:

(U) Every assignment has a minimal D-fusion.

(U) is the central claim of the argument from vagueness. According to the first half of the argument, (U) follows from considerations about indeterminacy. According to the second half of the argument, (U) entails Perdurantism. Let's take a look at each half in turn.

Let's use an example to get the gist of how (U) is supposed to follow from considerations about indeterminacy. Suppose that we have a top and a base, from which we put together a table at some time t_1 ; and suppose that we destroy the table at some later time t_2 . Then there is an object that the top and base compose from t_1 to t_2 , which exists exactly at that interval. Now, it seems that very minor changes in that situation would not prevent this from happening. That is, it seems that in a slightly different situation there would still be an object that is composed of the top and base throughout the interval, and that exists exactly then. For instance, it seems that if the top and base were a nanometer further apart from one another, they would still compose a thing throughout those times that exists exactly then. But then the same applies to this situation: it seems that if the top and base were yet another nanometer apart from one another, they would still compose something throughout those times that exists exactly then. And so on: by applying the same reasoning to any resulting alternative situation, we would get that in *any* situation whatsoever the top and base compose an object throughout the relevant interval that exists exactly then. This includes any situation in which the top and base are a gigameter apart from one another throughout some interval, as well as any situation in which they go back and forth from being a nanometer apart to being a gigameter apart throughout some interval. Otherwise, it would be arbitrary if a small change made a big difference at one point, so that the top and base compose something in one situation but not in a minimally different one. Or worse: at some point it would be indeterminate whether there is something composed of the top and base.

Sider generalizes this kind of reasoning as follows (2001, p. 134):

- (4-1) If not every assignment has a minimal D-fusion, then there must be a pair of cases which are connected by a continuous series, and in one of them, minimal D-fusion occurs, but in the other, minimal D-fusion does not occur.
- (4-2) In no continuous series is there a sharp cutoff.
- (4-3) In any case, either minimal D-fusion determinately occurs, or minimal D-fusion determinately does not occur.

A case is just a situation like those in the example of the top and base above, *i.e.* a possible situation involving some times t_1, t_2, \dots and some x s, some y s, \dots such that each of the x s is pervasively located at t_1 , each of the y s is pervasively located at t_2 , etc., and those objects have certain properties and stand in certain relations at each of t_1, t_2, \dots , as well as across them. A continuous series is a finite sequence of cases, such that each case in the sequence is only slightly different from the immediately adjacent ones in any respect that might be relevant as to whether the things involved have a minimal D-fusion. A sharp cutoff is a pair of immediately adjacent cases in a continuous series, such that in one of them the things in question determinately have a minimal D-fusion, but in the other the things in question determinately do not have a minimal D-fusion.

Now, here is how (U) is meant to follow from (4-1)-(4-3). Assume otherwise. Then by (4-1), there must be a case where minimal D-fusion occurs and one in which it does not, such that a continuous series connects them both. By (4-3), in each case in the series either minimal D-fusion determinately occurs, or it determinately does

not. But since minimal D-fusion does not occur at one end of the series, there must be a sharp cutoff somewhere in the continuous series, contrary to what (4-2) requires.

Let us now see how (U) is meant to entail Perdurantism. The basic idea is that minimal D-fusions are temporal parts of persisting objects. If a thing, x , is pervasively located at a time, t , then (U) requires that the assignment that assigns $\{x\}$ to t have a minimal D-fusion. That is, (U) requires that there be a thing, y , that is exactly located at t , and that is composed of x at t . By the definition of temporal parts, to show that y is a temporal part of x at t it suffices to show that y is part of x at t and that y overlaps at t every part of x at t . The latter follows straightforwardly from the definition of composition at a time and transitivity of temporally relativized parthood. The former follows from the definition of composition at a time and the following mereological principle (Sider 2001, p. 58):

(PO) For any x and y , if both x and y are located at t , and x is not part of y at t , then x has some part at t that does not overlap y at t .

So the claim is that Perdurantism follows from (U) given the relevant definitions and a certain principle governing temporally relativized parthood, since x and t were arbitrary.

This is, then, the argument from vagueness for Perdurantism. It contends that the existence of temporal parts follows from the claim that composition is unrestricted across times, which in turn follows from considerations about indeterminacy. Let us now see how the distinction between matters of mereology and matters of location undermines the argument.

4.2 Diachronic Composition vs. Diachronic Contraction

The objection I want to advance here grants that (U) follows from (4-1)-(4-3), as well as that Perdurantism follows from (U). However, it points out that (U) runs together matters of mereology and matters of relative spatiotemporal location, which foes of perdurantism may have independent motivation to distinguish between. To see this, let's first get an a bit more transparent account of D-fusions, minimal D-fusions, and (U).

Remember that a thing, x , is a D-fusion of an assignment f is just to say that x is composed of the members of $f(t_1)$ at t_1 , of the members of $f(t_2)$ at t_2 , of the members of $f(t_3)$ at t_3 , etc. And remember that an assignment, f , is just a function from times to classes of objects such that each of the members of $f(t)$ is pervasively located at t . So consider any times, $t_1, t_2, t_3 \dots$, and any pluralities of things, the x s, the y s, the z s, ..., such that each of the x s is pervasively located at t_1 , each of the y s is pervasively located at t_2 , each of the z s is pervasively located at t_3 , etc. Then to say that thing, x , is a D-fusion of the assignment that maps t_1 to the x s, t_2 to the y s, t_3 to the z s, etc. is just to say that x is composed of the x s at t_1 , of the y s at t_2 , of the z s at t_3 , etc. And to say that thing, x , is a minimal D-fusion of that assignment is just to say that x is composed of the x s at t_1 , of the y s at t_2 , of the z s at t_3 , etc. but that x is exactly located at the interval composed of $t_1, t_2, t_3 \dots$

This more explicit understanding of D-fusions and minimal D-fusions allows us to formulate (U) more transparently as follows:

(U*) For any times, $t_1, t_2, t_3 \dots$, and any pluralities of things, the x s, the y s, the z s, \dots , such that each of the x s is pervasively located at t_1 , each of the y s is pervasively located at t_2 , each of the z s is pervasively located at t_3 , etc. there exists a thing, x , that is composed of the x s at t_1 , of the y s at t_2 , of the z s at t_3 , etc. but that is exactly located at the interval composed of $t_1, t_2, t_3 \dots$

It also allows us make the crucial consequence of (U*) explicit, from which Perdurantism follows given the definition of temporal parts and (PO):

(4-4) For any object, x , and any time, t , at which x is pervasively located, there exists a thing, y , that is composed of x at t , and that is exactly located at t .

And it also allows us to make explicit another consequence of (U*) that will be central to what I want to say here:

(Arbitrary Diachronic Contraction)

For any object, x , and any time, t , at which x is pervasively located, there exists a thing, y , that is exactly located at t .

Now, let's focus on (U*) and Arbitrary Diachronic Contraction. Notice that there is something odd about the fact that the former requires the latter. (U*) was supposed to be a principle concerning diachronic composition, *i.e.* a principle according to which if we have some things at some times we get a thing that is made out of those things across those times. However, Arbitrary Diachronic Contraction is not concerned with joining things together. Quite the opposite: it concerned with cutting things up cross-temporally. So how come (U*), a principle that is meant to join

things arbitrarily across time, requires that things be sliced through arbitrarily across time? In other words, what does diachronic contraction have anything to do with diachronic composition? And of course: why should we accept a principle that runs these two things together? There would seem to be plenty of motivation to accept that we may arbitrarily join things across time without accepting that we arbitrarily cut them up cross-temporally, and the other way around.

The oddity of (U^*) springs from the notion of a minimal D-fusion. This is a strange notion: it not only concerns the existence of cross-temporal composites, but also imposes very strong constraints on where in time may such composites be located. That is, unlike the notion of a D-fusion, the notion of a minimal D-fusion is not a purely mereological notion: it mixes in mereology and location. To illustrate, consider some things that are pervasively located at some period of time; *e.g.* my nose and the Eiffel tower, which existed from Monday through Tuesday this week. Like the notion of a D-fusion, the notion of a minimal D-fusion concerns the existence of a thing that is composed of my nose and the Eiffel tower on Monday, the existence of a thing that is composed of my nose and the Eiffel tower on Tuesday, and the existence of a thing that is composed of my nose and the Eiffel Tower on both Monday and Tuesday. But unlike the notion of a D-fusion, the notion of a minimal D-fusion concerns the existence of a thing that is exactly located on Monday, the existence of a thing that is exactly located on Tuesday, and the existence of a thing that is exactly located on Monday through Tuesday. So unlike the notion of a D-fusion, the notion of a minimal D-fusion concerns not only cross-temporal composites, but also the exact location of those composites in time. It is because of this conflation of mereology and location that (U^*) not only poses the existence of arbitrary fusions of things across time, but also the existence of arbitrary contractions of things across time.

To make the oddity of (U*) yet more apparent, consider what an analogous principle would say in the case of spatiotemporal location generally, instead of only temporal location. Such a principle would entail a claim analogous to (4-4), according to which for any thing, x , and any region of spacetime, S , that x pervades, there is a thing, y , that is composed of x and that is exactly located at S . And from this it would follow not only that *e.g.* my nose has arbitrary proper contractions, but also, by the definition of composition, that my nose is part of each of its proper contractions. So such principle would mix matters of mereology and matters of location to the point of entailing some of the most radical violations of Parts \Rightarrow Contractions and of Fusions \Rightarrow Expansions that we saw in chapter 3. (U*) has exactly parallel consequences, only limited to the case of temporal location instead of spatiotemporal location generally.

It is clear, then, that (U*) runs together issues about mereology and issues about location. So it would be useful to distinguish it from a principle concerning mereology alone, which posits the existence of cross-temporal composites without setting restrictions on where in time such composites are located:

(Unrestricted Diachronic Composition)

For any times, $t_1, t_2, t_3 \dots$, and any pluralities of things, the x s, the y s, the z s, \dots , such that each of the x s is pervasively located at t_1 , each of the y s is pervasively located at t_2 , each of the z s is pervasively located at t_3 , etc. there exists a thing, x , that is composed of the x s at t_1 , of the y s at t_2 , of the z s at t_3 , etc.

This is what one may regard as unrestricted diachronic composition properly understood, devoid of issues concerning location. And notice that it is none other than the claim that every assignment has a D-fusion, *i.e.* universalism about D-fusions.

Now, as I mentioned above and as should be clear from our discussion in chapter 3, one may have perfectly good motivation to reject that things have arbitrary contractions across time; one may even do so while accepting that diachronic composition is unrestricted. That is, one may have perfectly good motivation to reject Arbitrary Diachronic Contractions and hence (U*), and one may even do so and accept Unrestricted Diachronic Composition. This is particularly salient given that the following is a coherent and well-motivated view on persistence: at least some persisting things are not only mereologically but also spatiotemporally simple, *i.e.* have an exact location with non-zero temporal extension but have neither proper parts nor proper contractions. This view would be analogous to the view that there are at least some extended simples that do not have proper contractions. And it would clearly dodge the argument from vagueness, without having to reject that either that (U) follows from (4-1)-(4-3) or that Perdurantism follows from (U), as well as without having to reject (PO), Unrestricted Diachronic Composition, Sider's definition of temporal parts, his formulation of perdurantism, etc.³

Notice, however, that if we rejected (U*) on the above grounds, but accepted that it follows from (4-1)-(4-3), we would still have to reject one of (4-1)-(4-3). Which,

³Moreover, given the possibility of compact fusions from chapter 3, the following is a coherent endurantist picture that is fully compatible with Unrestricted Diachronic Composition: all persisting objects, *i.e.* all things that pervade at least two times, have neither proper parts nor proper contractions. But there are unrestricted fusions of any such things which happen to be non-persisting objects, *i.e.* things that pervade only one time. So on this view nothing would have proper contractions, but any things would have a fusion. While this would be an odd version of endurantism, it is a coherent view, and illustrates another way in which Unrestricted Diachronic Contraction may be rejected even if one accepts Unrestricted Diachronic Composition.

though? Given the view on persistence I sketched above, on which at least some persisting things are both mereologically and spatiotemporally simple, (4-2) would be the one to go. For suppose that x is both mereologically and spatiotemporally simple, *i.e.* that it has neither proper parts nor proper contractions. Suppose, too, that x is exactly located at the temporal interval composed of times t_1, \dots, t_n . Then the assignment that assigns $\{x\}$ to each t_i would have a minimal D-fusion, *i.e.* x itself. But none of the minimally different assignments that assign $\{x\}$ to all but one t_i would have a minimal D-fusion, for that would require that x have proper contractions. In other words, (U^*) would be true of x and some temporal interval, but false of x and a slightly different temporal interval: while for t_1, \dots, t_n there would be something composed of x at each t_i (namely, x itself), for t_1, \dots, t_{n-1} there would be nothing composed of x at each t_i , for that would require that x not be spatiotemporally simple.

Now, Sider defends (4-2) on the following grounds (2001, p. 124):

there would seem to be something ‘metaphysically arbitrary’ about a sharp cutoff in a continuous series of cases [...] Why is there a cutoff here, rather than there? Granted, everyone must admit *some* metaphysically ‘brute’ facts [...] Nevertheless, *this* brute fact seems particularly hard to stomach.

However, from the example above it is clear that this charge of arbitrariness would not apply to the view I suggested: someone who held that some persisting things have neither proper parts nor proper contractions could not be accused of accepting metaphysical arbitrariness; she would simply disagree with the perdurantist as to how things persist. The perdurantist would thus have said nothing to pressure her to change her mind.

Thus, the argument from vagueness for temporal parts requires a much stronger view than the view that diachronic composition is unrestricted to go through. But such view effectively runs together matters of mereology and matters of location, which opponents of perdurantism may simply reject. Distinguishing, then, between such matters affords a new way of resisting the argument.

CHAPTER 5
MERELOGICAL INDETERMINACY AT LOGICALLY DETERMINATE
WORLDS

Prima facie, there is indeterminacy in the part-whole structure of the material world—it is indeterminate whether some material things bear certain part-whole relations to others. Consider, for instance, mount Kilimanjaro. Some rocks are determinately part of Kilimanjaro. Rocks near the top are determinately part of it, and so are rocks near the middle. And some rocks are determinately not part of Kilimanjaro. Rocks in the Ithaca gorges are determinately not part of it, and neither are rocks in Io, the largest Galilean moon of Jupiter. It seems, however, that not all rocks fall neatly into one of those two classes, *i.e.* the class of rocks that are determinately part of Kilimanjaro and the class of rocks that are determinately not part of it. That is, for some rocks, it seems to be indeterminate whether they are part of Kilimanjaro. For instance, some rocks near the base appear to be neither determinately nor determinately not part of it; if you wanted to take home a part of Kilimanjaro as a souvenir of your trip to Tanzania, you would be safer picking one near the middle or the top rather than one near the base. It seems, thus, that parthood may be indeterminate, at least as far as material objects are concerned: prima facie, there are pairs of material things such that it is indeterminate whether one is part of the other.

It seems that composition, too, may be indeterminate. Suppose, for instance, that exactly one rock in the universe is in the unfortunate position of being neither determinately nor determinately not part of Kilimanjaro; call it R. Now consider all the rocks that are determinately part of Kilimanjaro; call them *the rocks*. Then it seems that it is indeterminate whether the rocks and R compose Kilimanjaro. For the rocks

and R compose Kilimanjaro only if R is part of it, but it is indeterminate whether R is part of Kilimanjaro. For another kind of example, suppose that we are putting together a table. When the top and the base are far apart from one another, it seems that they determinately compose nothing. Once we attach the top to the base, it seems that they determinately compose something. But at some point as we are bringing the top and the base together, it seems to be indeterminate whether the top and base compose something: they neither determinately nor determinately not compose something. Thus, it looks like composition may also be indeterminate, at least as far as material things are concerned—*prima facie*, there are material things such that it is indeterminate whether they compose something.

It seems, then, that there is indeterminacy in the part-whole relations among material things, *i.e.* in the mereological structure of the material world. Some metaphysicians have recently argued, however, that there could not be such indeterminacy. The thought is that if there were, then there would also be indeterminacy in matters of identity, existence, and cardinality. But, the argument goes, there could not be indeterminacy in such matters. So, there could not be indeterminacy in matters of part and whole either. In other words, the idea is that indeterminacy in the mereological features of the material world requires indeterminacy in its *logical* features—those having to do with the identity, existence, and cardinality—but that there could not be indeterminacy in its logical features.

More specifically, foes of mereological indeterminacy have argued for the following claims (I leave the restriction to material things implicit):

(5-1) If parthood is indeterminate, then identity must also be indeterminate.

(5-2) If composition is indeterminate, then identity must also be indeterminate.

(5-3) If composition is indeterminate, then existence must also be indeterminate.

(5-4) If composition is indeterminate, then it must also be indeterminate how many things there are.

(5-5) Identity, existence, and cardinality could not be indeterminate.

The first four claims hold that certain forms of indeterminacy in the mereological structure of the material world require certain forms of indeterminacy in its mereological structure, *i.e.* that there is necessary connection between certain forms of mereological indeterminacy and certain forms of logical indeterminacy. (5-1) claims that indeterminate parthood requires indeterminate identity, while (5-2)-(5-4) claim that indeterminate composition requires indeterminate identity, indeterminate existence, and indeterminate cardinality. But (5-5) claims that there could not be such forms of indeterminacy in the logical structure of the material world, *i.e.* that there could not be indeterminate identity, indeterminate existence, or indeterminate cardinality. So from (5-1)-(5-5) it follows that there could not be such forms of indeterminacy in the part-whole structure of the material world either, *i.e.* that parthood and composition could not be indeterminate.

Here is the gist of the argument for both (5-1) and (5-2) (Weatherson 2003, Williams and Barnes forthcoming). Let R and the rocks be as in the example above. Now suppose that Kilimanjaro⁻ is a thing that the rocks determinately compose, and that Kilimanjaro⁺ is a thing that the rocks and R determinately compose. Then it seems that if it is indeterminate whether R is part of Kilimanjaro, then it must also be indeterminate whether Kilimanjaro = Kilimanjaro⁻, as well as whether Kilimanjaro = Kilimanjaro⁺. But if so, then indeterminate parthood requires indeterminate identity: if it is indeterminate whether a material thing is part of another, then it must

be indeterminate whether a material thing is identical to another. Similarly, it seems that if it is indeterminate whether Kilimanjaro is composed of the rocks and R, then it must also be indeterminate whether $\text{Kilimanjaro} = \text{Kilimanjaro}^-$, as well as whether $\text{Kilimanjaro} = \text{Kilimanjaro}^+$. But if so, then indeterminate composition requires indeterminate identity: if it is indeterminate whether some material things compose another, then it must be indeterminate whether some material thing is identical to another.

Here is the idea behind the argument for (5-3) and (5-4) (*e.g.* Sider 2001, 2003; Smith 2005). Consider the example of the table above. Now consider the base and the top as we bring them closer together. It seems that if it is indeterminate whether they compose something, then it must also be indeterminate whether some material thing exists. After all, when the base and the top are far apart from one another, it is determinate that there are no material objects in addition to the ones “already” there. And when the base and the top are attached, it is determinate that there is a material object in addition to the ones that were there already. But then if at some point when we are bringing the base and the top together it is indeterminate whether they compose something, then it is indeterminate whether there is a material thing in addition to the ones already there. But if so, if it is indeterminate whether some material things compose something, then it must indeterminate whether something exists. Similarly, it seems that if it is indeterminate whether the top and base compose something, then it must also be indeterminate how many material things there are, at least in worlds with only finitely many material things. For suppose that there are exactly n material things when the top and base are far apart from each other, for some finite n . Then there are at least $n+1$ material things when the top and base are brought together. So it seems that if it is indeterminate whether the base and top compose something, then

it must be indeterminate whether there are exactly n or exactly m material things, for some $m \geq n + 1$. But if so, if it is indeterminate whether some material things compose something, then it must be indeterminate how many material things there are. (The restriction to worlds with only finitely many material things here does not significantly affect the argument against mereological indeterminacy based on (5-1)-(5-5). For as Sider points out, if there may be indeterminacy in the mereological structure of the material world, then surely that may happen at worlds with finitely many material things (cf. Sider 2001). It would be rather odd indeed to think that it could happen only at worlds with at least denumerably many material things.)

Now, here is the gist of the argument for (5-5) (Lewis 1986; Sider 2001, 2003). The key claim is that all indeterminacy is semantic indeterminacy. If, for instance, it is indeterminate whether someone is bald, then it is because the predicate 'is bald' has different properties as precisifications or candidate meanings, not because it is ontologically indeterminate whether the person instantiates the property that 'is bald' determinately expresses, or because we are ignorant of the conditions under which someone instantiates that property. So the idea is that if existence, identity, or cardinality are indeterminate, then some relevant expression must have multiple precisifications. But since claims about the identity, existence, and cardinality of material things may be expressed with only logical vocabulary and the predicate for material thinghood, that would require that either some piece of logical terminology or the predicate for material thinghood have multiple precisifications. Assuming, for the sake of argument, that the predicate for material thinghood does not have multiple precisifications, it follows that some piece of logical vocabulary must have multiple precisifications. But, the argument goes, no piece of logical vocabulary has multiple precisifications.

Friends of indeterminate parthood and indeterminate composition have attempted to fend off this line of attack by trying to undermine the argument for (5-5). They have attempted to resist the argument by rejecting either that all indeterminacy is semantic (perhaps, for instance, there is ontological indeterminacy), or that no piece of logical terminology has multiple precisifications (perhaps, for instance, existential quantifiers have several candidate meanings).

This has been not only *one* strategy that friends of mereological indeterminacy have pursued, but also their *only* strategy. So far very little pressure has been put on (5-1)-(5-4) and the arguments for them. That is, until now no one has attempted to undermine the alleged necessary connection between indeterminacy in the part-whole structure of the material world and indeterminacy in its logical structure. My goal in this chapter is to do just that. I will argue that the possibility of external deviations allows for both parthood and composition to be indeterminate without identity, existence, and cardinality being indeterminate. The basic idea is that there may be worlds where relations of relative spatiotemporal location among material things are determinate, and where those relations fix the logical structure of the material world. But since mereological relations and relations of relative spatiotemporal location among material things may come apart per the possibility of external deviations, there may be indeterminacy in mereological relations without indeterminacy in relations of relative spatiotemporal location, and hence without indeterminacy in the logical structure of the material world. I will suggest, moreover, that this strategy is completely neutral as to what forms of indeterminacy there may be. So it undermines the above line of argument against mereological indeterminacy even if all indeterminacy is semantic indeterminacy and logical vocabulary has no precisifications, and so even if we grant the argument for (5-5).

Here is the plan. I will begin with a few preliminary remarks about determinacy and indeterminacy. This will allow us to get clear on what exactly it means to say that parthood, composition, identity, existence, and cardinality are indeterminate, which will in turn allow us to get clear on what exactly (5-1)-(5-4) are claiming and what are the arguments for them. With that setup, I will then show how the possibility of external deviations delivers counterexamples to those claims and undermines the arguments in their favor.

5.1 Determinacy and Indeterminacy

In the examples above we talked about determinacy and indeterminacy, *i.e.* about it being neither determinate that so-and-so nor determinate that not so-and-so, about it being indeterminate whether so-and-so, etc. This kind of talk about determinacy and indeterminacy makes use of a pair of propositional operators, *it is determinate that* and *it is indeterminate whether*. So it is important to make a few clarifications about these determinate-that and indeterminate-whether operators, about how they are connected to one another, and about how they are related to other determinacy and indeterminacy operators.

The determinate-that operator intuitively applies to all and only those propositions that hold determinately. The logical behavior of this operator is arguably exactly parallel to the logical behavior of the necessity operator in the S5 system of modal logic, but here I will only assume that it is governed by the K system. Using ‘ Δ ’ for the determinate-that operator, this means that the determinate-that operator obeys the following schemata:

(RN) $\phi \models \Delta \phi$.

(K) $\Delta(\phi \rightarrow \psi) \rightarrow (\Delta \phi \rightarrow \Delta \psi)$.

The indeterminate-whether operator intuitively applies to all and only those propositions that neither hold determinately nor fail to hold determinately. So the determinate-that and indeterminate-whether operators are linked to each other through the following principle: it is indeterminate whether so-and-so just in case it is neither determinate that so-and-so nor determinate that not so-and-so, which is the same as saying that it is not indeterminate whether so-and-so just in case it is either determinate that so-and-so or determinate that not so-and-so. Using ‘ ∇ ’ for the indeterminate-whether operator, this principle is as follows:

(5-6) $\nabla \phi \leftrightarrow (\neg \Delta \phi \ \& \ \neg \Delta \neg \phi)$.

This suggests that the indeterminate-whether operator behaves just as the contingency operator behaves in modal logic, which applies to all and only those propositions such that neither it nor its negation are necessarily true. This means that principles such as the following hold of the indeterminate-whether operator:

(5-7) $\Delta \phi \leftrightarrow \phi \ \& \ \neg \nabla \phi$

(5-8) $\nabla \phi \leftrightarrow \nabla \neg \phi$

(5-9) $\nabla(\phi \vee \psi) \leftrightarrow (\nabla \phi \vee \nabla \psi)$

From this it follows that the behavior of the indeterminate-whether operator is not parallel to the behavior of the possibility operator in familiar systems of modal logic;

in particular, the determinate-that and indeterminate-whether operators are not duals of each other. And for good reason: there are various principles you would want the possibility operator to be governed by that you would not want to hold of the indeterminacy-whether operator, and there are various principles you would want the indeterminacy-whether operator to abide by that you would not want to be true of the possibility operator. For instance, while in general it is arguably necessary that so-and-so iff it is not possible that not so-and-so, you would not want to say in general that it is determinate that so-and-so iff it is not indeterminate whether not so-and-so. Surely it is not determinate that Socrates is both tall and not tall, but it is not indeterminate whether Socrates is not both tall and not tall. Similarly, while in general you would want to say that it is indeterminate whether so-and-so iff it is indeterminate whether not so-and-so, surely it is not the case in general that it is possible that so-and-so iff it is possible that not so-and-so. For instance, it is possible that all tall things be tall, but surely it is not possible that not all tall things be tall.

Now, sometimes claims about indeterminacy are made with that- instead of whether- clauses, *i.e.* via locutions of the form “it is indeterminate that so-and-so”. Similarly, claims about determinacy are sometimes made with whether- instead of that- clauses, *i.e.* via locutions of the form “it is determinate whether so-and-so”. What is the connection between claims about indeterminacy-that and claims about indeterminacy-whether? And what is the connection between claims about determinacy-whether and claims about determinacy-that?

Claims concerning indeterminacy-that are arguably just claims about indeterminacy-whether; it is hard to think of grounds to distinguish between the content of the claim that it is indeterminate that so-and-so and the content of the

claim that it is indeterminate whether so-and-so. For instance, someone might introduce an operator that is the dual of the determinate-that operator (*i.e.* which holds of all and only those propositions the negation of which fails to hold determinately) and insist that claims about indeterminacy-that are better captured via this operator than via our indeterminate-whether operator. But that would be wrong. For the dual of the determinate-that operator would behave just as the possibility operator behaves in various systems of modal logic. And for reasons discussed above, no operator that behaves like the possibility operator could capture the content of claims about indeterminacy, whether they are expressed with that- or whether- clauses. You would not want to say that Socrates is tall only if it is indeterminate that Socrates is tall, just as you would not want to say that Socrates is tall only if it is indeterminate whether Socrates is tall.

On the other hand, there is a clear distinction between claims concerning determinacy-whether and claims concerning determinacy-that: the latter are stronger than the former. If it is determinate that Socrates is tall, then surely it is determinate whether Socrates is tall. But the converse does not hold: that it is determinate whether Socrates is tall does not imply that it is determinate that Socrates is tall. For it may be determinate whether Socrates is tall by it being determinate that Socrates is *not* tall. This suggests that determinacy-whether and determinacy-that are tied to one another through the following principle: it is determinate whether so-and-so just in case either it is determinate that so-and-so or determinate that not so-and-so. Using ‘ Δ_w ’ for the determinate-whether operator, this is to say the following:

$$(5-10) \Delta_w \phi \leftrightarrow (\Delta \phi \vee \Delta \neg \phi).$$

This means that the determinate-whether operator behaves just like the non-contingency operator behaves in modal logic. So it is governed by principles such as the following:

$$(5-11) \Delta_w \phi \leftrightarrow \Delta_w \neg \phi$$

It follows that various principles that regulate the behavior of the determinate-that operator do not hold of the indeterminate-whether operator, as well as that various principles that the determinate-whether operator abides by do not govern the determinate-that operator. And, once again, for good reason. For instance, you would not want (K) to hold of indeterminacy-whether: surely it is determinate whether Socrates's being both tall and not tall implies that Socrates is tall, and surely it is determinate whether Socrates is both tall and not tall. But you would not want to conclude from this that it is determinate whether Socrates is tall. Similarly, you would not want (5-11) to hold of determinacy-that. Surely it is determinate that all tall things are tall, but it is not determinate that not all tall things are tall.

Given this connection between the determinate-that and determinate-whether operators, it follows that the determinate-whether and indeterminate-whether operators are duals of each other. That is, it follows both that it is determinate whether so-and-so just in case it is not indeterminate whether not so-and-so, and that it is indeterminate whether so-and-so just in case it is not indeterminate whether not so-and-so:

$$(5-12) \Delta_w \phi \leftrightarrow \neg \nabla \neg \phi.$$

$$(5-13) \nabla \phi \leftrightarrow \neg \Delta_w \neg \phi.$$

In fact, both (5-12) and (5-13) follow directly from (5-6) and (5-10) alone.¹ Similarly, it follows that the determinate-whether and indeterminate-whether operators are contraries of each other. That is, it follows both that it is determinate whether so-and-so just in case it is not indeterminate whether so-and-so, and that it is indeterminate whether so-and-so just in case it is not indeterminate whether so-and-so:

$$(5-14) \Delta_w \phi \leftrightarrow \neg \nabla \phi.$$

That the determinate-whether and indeterminate-whether are both duals and contraries of each other seems right on intuitive grounds: surely it is determinate whether Socrates is tall just in case it is not indeterminate whether Socrates is not tall, and it is indeterminate whether Socrates is tall just in case it is not determinate that Socrates is not tall. Similarly, surely it is determinate whether Socrates is tall just in case it is not indeterminate whether Socrates is tall. So the lack of parallelism between the connection between determinacy-that and determinacy-whether, on the one hand, and the connection between indeterminacy-whether and indeterminacy-that, on the other, should not raise worries.

Now, getting clear on all these notions concerning determinacy and indeterminacy is of general importance, given that their logical behavior and the connections

¹Here is the proof. Consider the following instance of (5-6), and the following two instances of (5-10):

$$(5-6^*) \nabla \neg p \leftrightarrow (\neg \Delta \neg p \ \& \ \neg \Delta \neg \neg p).$$

$$(5-10^*) \Delta_w p \leftrightarrow (\Delta p \ \vee \ \Delta \neg p).$$

$$(5-10^{**}) \Delta_w \neg p \leftrightarrow (\Delta \neg p \ \vee \ \Delta \neg \neg p).$$

Since the right-hand sides of (5-6*) and (5-10**) are the negations of each other, from them it follows that $\Delta_w \neg p \leftrightarrow \neg \nabla \neg p$. Since the right-hand sides of (5-10*) and (5-10**) are equivalent (remember that given (RN) and (K), double negations may be added and eliminated freely within the scope of ' Δ '), their left-hand sides are also equivalent, *i.e.* $\Delta_w p \leftrightarrow \Delta_w \neg p$. But this claim and the one we got from (5-6*) and (5-10**) entail by transitivity of equivalence that $\Delta_w p \leftrightarrow \neg \nabla \neg p$. Since p was arbitrary, (5-12) follows. The proof that (5-13) follows is exactly parallel, given the appropriate instances of (5-6) and (5-10).

between them are often poorly understood in the literature. For instance, both Gibbins (1982) and Pelletier (1984, 1989) claim that S5 is not the logic of the determinate-that operator; Pelletier goes as far as to claim that it violates (K), and so that its logic is not even normal. But both authors fail to recognize the distinction between determinacy-that and determinacy-whether: their arguments clearly conflate between both operators. This confusion is also manifest in much of the literature generated by Evans's so-called argument against vague objects, where the determinate-that and indeterminate-whether operators are widely taken to be duals of each other (Evans 1978).

On the other hand, getting clear on all these issues concerning determinacy and indeterminacy will be particularly useful for our purposes here. For in order to understand what exactly (5-1)-(5-4) claim and assess whether they are true, we first need to get clear on what exactly it means to say in general that parthood, composition, identity, existence, and cardinality are indeterminate. And as we will see below, a proper general understanding of determinacy and determinacy affords valuable tools to precisely characterize these notions and to address issues that have remained uncovered in the literature. Let's then move on to these notions.

5.2 Indeterminacy in Mereological Structure

Given our indeterminate-whether operator, we may cash out what it means to say that parthood and composition are indeterminate as follows:

(5-15) It is indeterminate whether a thing is part of another.

(5-16) It is indeterminate whether some things compose another.

However, (5-15) and (5-16) are still far from being adequate accounts of indeterminate parthood and indeterminate composition. For as we will see below, there is more to these claims than might be apparent. Let's begin with indeterminate parthood, and then move on to indeterminate composition.

Notice that (5-15) has three readings. On the first reading, the claim is that it is indeterminate whether for a pair of things, one is part of the other. On the second reading, the claim is that for some thing, it is indeterminate whether something is part of it. On the third reading, the claim is that for a pair of things, it is indeterminate whether one is part of the other. These are as follows:

(5-15a) $\nabla \exists x \exists y$ x is part of y .

(5-15b) $\exists x \nabla \exists y$ x is part of y .

(5-15c) $\exists x \exists y \nabla$ x is part of y .

Does this mean that there are three different notions of indeterminate parthood, one corresponding to each reading of (5-15)? No: only the third reading affords an in principle viable characterization of indeterminate parthood. To see this, focus on what the first two say. (5-15a) says that it is indeterminate whether there is a thing with parts. But this claim is false in any situation in which it is determinate that something exists. For it is determinate that anything whatsoever has at least one part, *i.e.* itself. So if it is determinate that something exists, then it is not indeterminate whether there is a thing with parts, which is another way of saying that (5-15a) is false. Put

another way, the following claim is always true: $\Delta \forall x \exists y x$ is part of y .² So the following claim is true in any situation in which it is determinate that there is something: $\Delta \exists x \exists y x$ is part of y . But by (5-6) this claim entails the following one, which is just the negation of (5-15a): $\neg \nabla \exists x \exists y x$ is part of y . Now, since (5-15a) is false in any situation in which something determinately exists, it cannot provide an adequate account of indeterminate parthood: it should be in principle possible for parthood to be indeterminate even if there are things that determinately exist.

Similarly, (5-15b) says that there exists a thing such that it is indeterminate whether it has parts. But this can never be true. For it is always true that for anything whatsoever it is determinate that it has at least one part, *i.e.* itself. So for any object whatsoever, it is not indeterminate whether something is part of it, and this is just another way of saying that (5-15b) is false. Put another way, (5-15b) is incompatible with the following claim, which is always true: $\forall x \Delta \exists y x$ is part of y .³ By (5-6), this claim entails the following one, which is equivalent to the negation of (5-15b): $\forall x \neg \nabla \exists y x$ is part of y .

So the only viable way of characterizing indeterminate parthood is via (5-15c), *i.e.* there is only one notion of indeterminate parthood: parthood is indeterminate when there is a pair of things such that it is indeterminate whether one is part of the other.

That is:

²This is always true taking reflexivity of parthood as a given. To see why, notice that if it is a given that $\forall x x$ is part of x , then by (RN) it follows that $\Delta \forall x x$ is part of x . Also by (RN), all logical truths are determinate; so since it is a logical truth that $(\forall x x \text{ is part of } x) \rightarrow (\forall x \exists y x \text{ is part of } y)$, it follows that $\Delta ((\forall x x \text{ is part of } x) \rightarrow (\forall x \exists y x \text{ is part of } y))$. So by (K), it follows that $\Delta \forall x \exists y x$ is part of y .

³This is always true also taking reflexivity of parthood as a given. Notice that if it is a given that $\forall x x$ is part of x , it follows that a is part of a , for an arbitrary a . By (RN) it follows that Δa is part of a . Also by (RN) it follows that $\Delta (a \text{ is part of } a \rightarrow \exists y a \text{ is part of } y)$. So by (K), it follows that $\Delta \exists y a$ is part of y . Since a was arbitrary, it follows that $\forall x \Delta \exists y x$ is part of y .

(Indeterminate Parthood)

Parthood is indeterminate iff for some pair of things, x and y , it is indeterminate whether x is part of y .

And notice that this is exactly what is supposed to be going on in the example of Kilimanjaro and R we saw at the outset. For in that case there is a pair of things, Kilimanjaro and R , such that it is indeterminate whether R is part of Kilimanjaro.

Having gotten clear on indeterminate parthood, let's move on to indeterminate composition. Like with (5-15), there are three readings of (5-16) :

(5-16a) $\nabla \exists x s \exists y$ x s compose y .

(5-16b) $\exists x s \nabla \exists y$ x s compose y .

(5-16c) $\exists x s \exists y \nabla$ x s compose y .

The first one is not a viable way of characterizing indeterminate composition, for the same reason that (5-15a) is not a viable way of characterizing indeterminate parthood. (5-16a) says that it is indeterminate whether there are things that compose something. But this can never be true provided that something determinately exists, for it is determinate that any plurality of exactly one thing composes something, *i.e.* the object in that plurality.⁴ So (5-16a) can never be true provided that something determinately exists. Unlike (5-15b) in the case of parthood, however, (5-16b) does not conflict with any trivial truths. (5-16b) says that for some things it is indeterminate whether there is something that they compose. It is always true that for every

⁴The proof of this is exactly parallel to the proof given footnote 2 above, given that reflexivity of parthood and the definition of composition.

plurality of exactly one thing it is not indeterminate whether it composes something, but this clearly does not hold trivially for *any* pluralities. So unlike (5-15b) in the case of indeterminate parthood, (5-16b) is a viable way of characterizing indeterminate composition. And like (5-15c) in the case of indeterminate parthood, (5-16c) is a viable way of characterizing indeterminate composition.

(5-16b) and (5-16c) in fact suggest that there are two ways in which composition may be indeterminate, *i.e.* two forms or varieties of indeterminate composition. For some things it may be indeterminate whether there is an object that those things compose. And for some things and some object, it may be indeterminate whether those things compose that object. I call these two forms of indeterminate composition *de dicto* indeterminate composition and *de re* indeterminate composition, respectively, given the scopal interactions between the singular existential quantifier and indeterminate-whether operator in (5-16b) and (5-16c):

(*De Dicto* Indeterminate Composition)

Composition is *de dicto* indeterminate iff for some things, the *x*s, it is indeterminate whether there is a thing, *y*, that the *x*s compose.

(*De Re* Indeterminate Composition)

Composition is *de re* indeterminate iff for some things, the *x*s, and some thing, *y*, it is indeterminate whether the *x*s compose *y*.

Notice that these two ways in which composition may be indeterminate were already manifest in the examples discussed at the outset. In the example in which we put together a table, at some point it is indeterminate whether the base and the top compose something. But it is so not because there is something such that it is indeterminate

whether the base and the top compose it. Rather, it is indeterminate whether the base and the top compose something because it is indeterminate whether there is something that they compose. By contrast, in the Kilimanjaro example it is indeterminate whether the rocks and R compose something, *i.e.* Kilimanjaro. But this does not mean that the rocks and R are such that it is indeterminate whether there is something that they compose. It only means that the rocks, R, and Kilimanjaro are such that it is indeterminate whether they compose it.

How are these two forms of indeterminate composition related to one another? If composition is *de dicto* indeterminate, must it also be *de re* indeterminate? And if composition is *de re* indeterminate, must it also be *de dicto* indeterminate? The answer to both questions is *no*. To see this, first notice that they may be related in either a stronger or a weaker way:

(Strong Link)

For any *xs*, it is indeterminate whether there is a *y* that the *xs* compose iff there is a *y* such that it is indeterminate whether the *xs* compose *y*.

(Weak Link)

For some *xs* it is indeterminate whether there is a *y* that the *xs* compose iff for some *xs* there is a *y* such that it is indeterminate whether the *xs* compose *y*.

Strong Link claims that it is *de dicto* indeterminate whether some things compose an object exactly when it is *de re* indeterminate whether *those* things compose an object. By contrast, Weak Link only requires that there be *de dicto* vague composition exactly when there is *de re* vague composition. So it is clear that Strong Link entails

Weak Link. Because of this, if either direction of Weak Link fails, then so does the corresponding direction of Strong Link.

Let's first see why the right-to-left direction of Weak Link fails. Notice that there may be some x s and some y such that it is indeterminate whether the x s compose y even if for any things, the x s included, it is not indeterminate whether there is something that those things compose—all that is required for consistency is that it be determinate that there is an object that the x s compose, and that such an object not be identical to y . Using the Kilimanjaro example: it may be indeterminate whether the rocks and R compose Kilimanjaro even if for any things, the rocks and R included, it is not indeterminate whether there is something that those things compose: all we need is that it be determinate that there is an object that the rocks and R compose, and that such an object not be Kilimanjaro. Let's now see why the left-to-right direction fails. Notice that there may be some x s such that it is indeterminate whether there is a y that the x s compose even if for any things, the x s included, and any object, it is not indeterminate whether those things compose that object—all that is required for consistency is that for any object it be determinate that the x s do *not* compose that object. Using the Kilimanjaro example: it may be indeterminate whether there is something composed of the rocks and R even if for any things, the rocks and R included, and any object, it is not indeterminate whether those things compose that object—all we need for consistency is that for any object, it be determinate that the rocks and R do *not* compose that object.

It follows, then, that the distinction between *de dicto* and *de re* indeterminate composition is far from superficial: they are logically independent of each other in both the weaker and the stronger sense. This means that one may in principle accept that

there is indeterminate composition of one form without accepting that there is indeterminate composition of the other form. As we will see, this will be important in getting clear on what is at issue in (5-2)-(5-4). But the distinction between *de dicto* and *de re* indeterminate composition is also of general interest in metaphysics, for philosophers in the recent literature have confused between them. For instance, consider the discussion over the Lewis-Sider so-called argument from vagueness for unrestricted composition (Lewis 1986, 212-13; Sider 2001, 121-32). As I mentioned at the outset in chapter 4, the claim that composition may not be indeterminate is a key premise of that argument. Neither Lewis nor Sider distinguish between *de dicto* and *de re* indeterminate composition. Nonetheless, it is clear that their argument concerns *de dicto* indeterminate composition. However, some metaphysicians have objected to the argument by assuming that it concerns *de re* indeterminate composition (see e.g. Donnelly forthcoming). No matter how good those objections might be, they are off-target—at best, they hit only the strawman because they fail to recognize the distinction between *de re* and *de dicto* indeterminate composition.

We now have a better understanding of indeterminate parthood and the two ways in which composition may be indeterminate. To get the full picture on these three forms of mereological indeterminacy, let's now see how indeterminate parthood is connected to both *de dicto* and *de re* indeterminate composition.

From the discussion about the independence of *de dicto* and *de re* indeterminate composition, it is easy to see that indeterminate parthood is independent of *de dicto* indeterminate composition. However, it is not so with *de re* indeterminate composition: while *de re* indeterminate composition does not require indeterminate parthood, indeterminate parthood does require indeterminate composition. That inde-

terminate parthood requires *de re* indeterminate composition follows directly from the definition of composition, (RN), (K), and (5-6). Consider an arbitrary pair of things, x and y . By the definition of composition, x and y compose y only if x is part of y . So by (RN), this holds determinately. But then by (K) and (5-6), it is indeterminate whether x is part of y only if it is indeterminate whether x and y compose y . To see why *de re* indeterminate composition does not require indeterminate parthood, consider the Kilimanjaro example again. Notice that for it to be indeterminate whether the rocks and R compose Kilimanjaro it is sufficient that for some part, y , of Kilimanjaro it be indeterminate whether there is something that y and at least one of the rocks and R have as a common part (again by the definition of composition, (RN), (K), and (5-6)). But clearly it being indeterminate whether there is something that y and at least one of the rocks and R have as a common part does not require that for some pair of objects (whether or not it includes any of the rocks and R) it be indeterminate whether one is part of the other. So it may be indeterminate whether the rocks and R compose Kilimanjaro even if for any pair of things it is not indeterminate whether one is part of the other.

It follows, then, that only one of our three forms of mereological indeterminacy requires another: if parthood is indeterminate, then composition must be *de re* indeterminate. Other than this, there may in principle be any form of indeterminacy in the part-whole structure of the material world without there being any other.

Having gotten clear on what it means to say that parthood and composition are indeterminate, and on how the relevant three notions are related to one another, let's move on to indeterminate identity, indeterminate existence, and indeterminate cardinality.

5.3 Indeterminacy in Logical Structure

As with indeterminate parthood and indeterminate composition, we may characterize indeterminate identity, indeterminate existence, and indeterminate cardinality in terms of the indeterminate-whether operator:

(5-17) It is indeterminate whether a thing is identical to another.

(5-18) It is indeterminate whether something exists.

(5-19) It is indeterminate whether there are exactly n things.

But as we saw in the mereological case, claims of this sort need to be further spelled out. Let's begin with the one about indeterminate identity.

Like with (5-15) and (5-16), (5-17) has three readings:

(5-17a) $\nabla \exists x \exists y x = y$.

(5-17b) $\exists x \nabla \exists y x = y$.

(5-17c) $\exists x \exists y \nabla x = y$.

Like in the case of parthood, neither of the first two claims is a viable way of characterizing indeterminate identity. (5-17a) says that it is indeterminate whether something is identical to something. This can never be true provided that it is determinate that there is something, since it is always determinate that everything is identical to something, *i.e.* itself. (5-17b) says that for some thing it is indeterminate whether something is identical to it. This can never be true either, since for everything it is determinate that there is something identical to it, *i.e.* itself. So, like (5-15c) in the

case of parthood, (5-17c) affords the only viable way of characterizing indeterminate identity:

(Indeterminate Identity)

Identity is indeterminate iff for a pair of things, x and y , it is indeterminate whether $x = y$.

And this is just what is supposed to be going on in the cases of indeterminate identity mentioned at the outset. The idea was that if it is indeterminate whether R is part of Kilimanjaro, or whether the rocks and R compose Kilimanjaro, then it must also be indeterminate whether $\text{Kilimanjaro} = \text{Kilimanjaro}^-$, as well as whether $\text{Kilimanjaro} = \text{Kilimanjaro}^+$. These are indeterminate identities in the sense above: for a pair of things, it is indeterminate whether one is identical to the other.

Characterizing indeterminate existence is much less straightforward, and it will be easier to do so once we have a grip on indeterminate cardinality. So let's account for that notion first. Consider the standard first-order rendering of the claim that there are exactly n things:

$$(5-20) \exists x_1 \dots \exists x_n ((x_1 \neq x_2 \ \& \dots \ \& \ x_{n-1} \neq x_n) \ \& \ \forall y (x_1 = y \vee \dots \vee x_n = y))$$

This suggests that (5-19) has two readings:

$$(5-19a) \nabla \exists x_1 \dots \exists x_n ((x_1 \neq x_2 \ \& \dots \ \& \ x_{n-1} \neq x_n) \ \& \ \forall y (x_1 = y \vee \dots \vee x_n = y))$$

$$(5-19b) \exists x_1 \dots \exists x_n \nabla ((x_1 \neq x_2 \ \& \dots \ \& \ x_{n-1} \neq x_n) \ \& \ \forall y (x_1 = y \vee \dots \vee x_n = y))$$

The first one claims that for some n , it is indeterminate whether there are at least n things and at most n things, *i.e.* whether there are exactly n things. The second one claims that for some n and some things, it is indeterminate whether there are at least n such things and there are at most as many objects as there are such things. Only the first one is an in principle viable account of indeterminate cardinality. To see why the second one does not, notice, on the one hand, that it may be determinate that there are exactly n things even if for some things it is indeterminate whether there are at least n of them. On the other hand, it may be indeterminate how many things there are even if for any x_1, \dots, x_n it is determinate that either $x_1 = x_2$, or \dots or $x_{n-1} = x_n$, or there is a y such that $y \neq x_1$ and \dots and $y \neq x_n$. For instance, let $n = 2$, where $x_1 = x_2 = \text{my nose}$. Then such disjunction holds determinately, but it could still be indeterminate whether there are exactly two things. Thus, indeterminate cardinality must be characterized as follows:

(Indeterminate Cardinality)

Cardinality is indeterminate iff for some n , it is indeterminate whether there are exactly n material things.

And this is what seems to be going on in the example discussed at the outset. The thought was that if at some point when we are putting a table together it is indeterminate whether the top and base compose something, then it is also indeterminate how many things there are. The latter claim is just the claim that for some number (*e.g.* the number of things there were when the top and bottom were scattered in the room), it is indeterminate whether there are exactly that many things.

Let's finally move on to indeterminate existence. To see why this notion is much harder to characterize than the previous ones, consider the simplest first-order, predicate-free way of cashing out the claim that something exists, according to which something exists iff something is identical to itself:

(5-21) Something exists iff $\exists x x = x$.

This suggests that (5-18) is to be construed in one of the following two ways:

(5-21a) $\nabla \exists x x = x$.

(5-21b) $\exists x \nabla x = x$.

The first claim says that it is indeterminate whether something is identical to itself. (5-21a) fails for the same reason (5-17a) fails: it can never be true provided that it is determinate that something exists. Someone might think, however, that this is not an appropriate objection to (5-21a), since the objection assumes that something determinately exists, when (5-21a) is supposed to characterize indeterminate existence. But this is misguided: it being determinate whether something exists should be in principle compatible with some things existing determinately. For instance, it being indeterminate whether something exists at some point when we are putting a table together should be in principle compatible with both the top and bottom existing determinately. On the other hand, (5-21b) can never be true at all. For it is determinate that everything is identical to itself, and so for anything whatsoever it is determinate that it is self-identical.

Of course, there are other first-order, predicate-free ways of cashing out the claim that something exists. Consider the following, for instance:

(5-22) Something exists iff $\exists x \exists y x = y$.

But this suggests that indeterminate existence ought to be characterized in one of the ways given in (5-17a)-(5-17c). None of these claims, however, provides a viable account of indeterminate existence. As we saw above, the first two are always false. And while the third one provides a viable characterization of indeterminate identity, indeterminate existence is *prima facie* a different notion altogether. Whatever indeterminate existence may be, it seems that it need not be indeterminate whether something exists simply because there is a pair of things such that it is indeterminate whether one is identical to the other. Similarly, it seems that for some pair of things it need not be indeterminate whether one is identical to the other simply because it is indeterminate whether something exists.

Now, we need not limit ourselves to first-order, predicate-free resources to express that something exists. If, for instance, we spelled out the claim that something exists either via a first-order existence predicate (*i.e.* an existence predicate other than the one given by the open formula $\exists y y = x$) or by using second-order resources, perhaps we could give viable characterization of indeterminate existence. The former, Meinongian or noeist strategy is this:

(5-23) Something exists iff $\exists x x$ exists.

So this suggests that indeterminate existence is to be accounted for in one of the following two ways:

(5-23a) $\nabla\exists x$ x exists.

(5-23b) $\exists x\nabla x$ exists.

The first claim would not properly characterize indeterminate existence, for the same reason that (5-21a) fails: *prima facie*, it may be indeterminate whether something exists even if it is determinate that there is something. The second is viable. However, it is objectionable on independent grounds—characterizing indeterminate existence in such a way that it is entangled with a number of difficult issues from the get-go would be a methodologically poor way to proceed.

The second-order, Fregean strategy is this:

(5-24) Something exists iff $\exists F\exists x$ x is F .

The idea is then that indeterminate existence is to be characterized in one of the following ways:

(5-24a) $\nabla\exists F\exists x$ x is F .

(5-24b) $\exists F\nabla\exists x$ x is F .

(5-24c) $\exists F\exists x\nabla x$ is F .

But none of these claims would do to characterize indeterminate existence. With respect to (5-24a), *prima facie* it may be indeterminate whether something exists even if it is determinate that something has some property, *e.g.* even if it is determinate that Socrates is human. That is, indeterminate existence should not to be incompatible with it being determinate that Socrates is human. (5-24b) fails because *prima facie* it

may be indeterminate whether something exists even if for every property, it is determinate that something has that property. In other words, indeterminate existence does not seem to be incompatible with every property being determinately instantiated by something or other. And (5-24c) fails because *prima facie* it may fail to be indeterminate whether something exists even if for some property and some thing it is indeterminate whether that thing has that property, *e.g.* even if it is indeterminate whether Socrates is tall.

The prospects of giving a precise and viable characterization of indeterminate existence are starting to look bleak. The Meinongian or noeist account via (5-23b) seems to be the more promising one, even though it handicaps indeterminate existence from the get-go by associating with a host of difficult issues. Must we conclude that a non-Meinongian or noeist notion of indeterminate existence is ineffable, or worse, incoherent?

No: thinking about indeterminate identity and indeterminate finite cardinality affords a limited yet viable and non-Meinongian characterization of indeterminate existence, which will be good enough for our purposes. In general, it may be determinate how many things there are even if either identity or existence are indeterminate. For instance, it may be determinate that there are denumerably many objects even if for a pair of those objects it is indeterminate whether one is identical to the other, as well as even if it is indeterminate whether there is one more thing. But arguably this could not happen if we consider only finite cardinalities: if it is determinate that there are only finitely many things, and either identity or existence is indeterminate, then it must be indeterminate how many things there are.⁵ For instance, suppose that it

⁵Notice that it is not incoherent to suppose that it is determinate that there only finitely many things, but that it's indeterminate how many. For instance, it being determinate that there are either exactly two, etc. things is perfectly compatible with it being indeterminate whether there are exactly n things, for any

is determinate that there is at least one thing, and that it is determinate that there are at most two things. Suppose, too, that it is determinate that x and y exist. Then if it is indeterminate whether $x = y$, it must be indeterminate whether there is exactly one thing, as well as indeterminate whether there are exactly two things. And if it is determinate that $x = y$ but indeterminate whether something exists, then it must also be indeterminate whether there is exactly one thing, as well as indeterminate whether there are exactly two things.⁶ Moreover, arguably the connection also holds the other way around: if it is determinate that there are only finitely many things, but it is indeterminate how many things there are, then either identity or existence must be indeterminate. For instance, suppose again that it is determinate that there is at least one thing, that it is determinate that there are at most two things, and that it is determinate that x and y exist. Then if it is indeterminate whether there are exactly two things, then it must be indeterminate whether $x = y$, or whether something exists. So arguably indeterminate identity, indeterminate existence, and indeterminate finite cardinality are connected to each other through the following principle:

- (5-25) Necessarily, if it is determinate that there are only finitely many things, then it is indeterminate how many things there are iff either identity or existence is indeterminate.

This principle suggests that we may give a viable, non-Meinongian account of indeterminate existence for at least finite worlds in terms of two notions that we have already characterized: indeterminate identity and indeterminate cardinality. The idea

finite n .

⁶Per the previous note, it should be clear that it is not incoherent to suppose that it is determinate there are at least m and at most n things, but that it is indeterminate whether there are exactly k things, for any finite m, n, k with $m \neq n$ and $m \leq k \leq n$.

is that if there are finitely many things, then existence is indeterminate iff cardinality is indeterminate but identity is not. That is, if there are only finitely many things, then:

(Indeterminate Existence)

Existence is indeterminate iff for some n , it is indeterminate whether there are exactly n things, but for no pair of things, x and y , it is indeterminate whether $x = y$.

This limited account is enough for our purposes because, as mentioned at the outset, the restriction to worlds with only finitely many material things does not significantly affect the argument against indeterminacy in the mereological structure of the material world based on (5-1)-(5-5): if either parthood or composition may be indeterminate among material things, then surely they may be so at worlds with only finitely many material things. Of course, one might still wonder whether there is a perfectly general non-Meinongian account of indeterminate existence. In light of the failed efforts above, it is reasonable to be skeptical about this.

We now have a better understanding of what it means to say that parthood, composition, identity, existence, and cardinality are indeterminate, as well as of a few important connections between some of these notions. Let us now see how they come into play in (5-1)-(5-4) and the arguments in their favor.

5.4 From Indeterminacy in Mereological Structure to Indeterminacy in Logical Structure

Remember that the general idea behind (5-1)-(5-4) is that certain forms of indeterminacy in the mereological structure of the material world require certain forms of indeterminacy in its logical structure. Given our accounts of the notions at issue in these claims, we may now get clearer on what exactly they claim.

(5-1) is straightforward given our characterizations of indeterminate parthood and indeterminate identity. It claims that if for some pair of material things it is indeterminate whether one is part of the other, then for some pair of material things it must be indeterminate whether one is identical to the other. In other words, (5-1) holds that:

- (1) Necessarily, if for some pair of material things, x and y , it is indeterminate whether x is part of y , then for some pair of material things, x and y , it is indeterminate whether $x = y$.

(5-2)-(5-4) are less straightforward, given that we have distinguished between *de dicto* and *de re* indeterminate composition. Which form of indeterminate composition is at issue in each claim?

The idea behind (5-2) was that if it is indeterminate whether the rocks and R compose Kilimanjaro, then it must also be indeterminate whether Kilimanjaro = Kilimanjaro⁻, as well as indeterminate whether Kilimanjaro = Kilimanjaro⁺. So it is clear that what is at stake here is *de re* indeterminate composition, not *de dicto*

indeterminate composition. So (5-2) claims that *de re* indeterminate composition requires indeterminate identity. That is, (5-2) claims that:

- (II) Necessarily, if for some material things, the x s, and some material thing, y , it is indeterminate whether the x s compose y , then for some pair of material things, x and y , it is indeterminate whether $x = y$.

Now, the idea behind (5-3) and (5-4) was that if at some point when we are bringing the top and base together it is indeterminate whether they compose something, then it must also be indeterminate whether something exists, as well as how many things there are. It is clear that what is at stake here is *de dicto* indeterminate composition, not *de re* indeterminate composition. So (5-3) and (5-4) claim that *de dicto* indeterminate composition requires indeterminate existence and indeterminate cardinality. Given (5-25), this to say that (5-3) and (5-4) make the following claims, respectively:

- (III) Necessarily, if there are only finitely many material things, and for some material things it is indeterminate whether there is something that they compose, but for no pair of material things, x and y , it is indeterminate whether $x = y$, then for some finite n it is indeterminate whether there are exactly n material things.
- (IV) Necessarily, if there are only finitely many material things and for some material things it is indeterminate whether there is something that they compose, then for some finite n it is indeterminate whether there are exactly n things.

With this clearer understanding of (I)-(IV), we may also spell out the arguments in their favor a bit better. Let's first revisit the argument for (I) and (II). The argument is that these claims hold assuming only certain principles of classical logic and

classical extensional mereology; in particular, excluded middle and uniqueness of composition (Weatherson 2003, Williams and Barnes forthcoming). Let's use to the Kilimanjaro example; remember that R is ex-hypothesi the only rock such that it is indeterminate whether it is part of Kilimanjaro, the rocks is the plurality of all and only those rocks that are determinately part of Kilimanjaro, Kilimanjaro^- is a thing determinately composed of the rocks, and Kilimanjaro^+ is a thing determinately composed of the R and the rocks. Now consider the following claims:

- (5-26) Either R is part of Kilimanjaro, or it is not.
- (5-27) If R is part of Kilimanjaro, then some things compose both Kilimanjaro and Kilimanjaro^+ .
- (5-28) If some things compose both Kilimanjaro and Kilimanjaro^+ , then $\text{Kilimanjaro} = \text{Kilimanjaro}^+$.
- (5-29) If R is not part of Kilimanjaro, then some things compose both Kilimanjaro and Kilimanjaro^- .
- (5-30) If some things compose both Kilimanjaro and Kilimanjaro^- , then $\text{Kilimanjaro} = \text{Kilimanjaro}^-$.
- (5-31) Either $\text{Kilimanjaro} = \text{Kilimanjaro}^+$ or $\text{Kilimanjaro} = \text{Kilimanjaro}^-$.

The argument goes as follows: (5-26) holds by excluded middle, and it holds determinately by (RN). Given the definition of composition and uniqueness of composition, (5-31) follows from (5-26); so by (RN) (5-26) holds only if (5-31) does. But since (5-26) holds determinately, by (K) so does (5-31). Now, since (5-31) is a disjunction, it can hold determinately only if either at least one disjunct holds determinately or it is indeterminate whether each disjunct holds. But if it is indeterminate whether

R is part of Kilimanjaro, then by Leibniz's Law neither disjunct holds determinately, since it is neither indeterminate whether R is part of Kilimanjaro⁺ nor indeterminate whether R is part of Kilimanjaro⁻. So if it is indeterminate whether R is part of Kilimanjaro, it follows that it is indeterminate whether Kilimanjaro=Kilimanjaro⁺ as well as whether Kilimanjaro=K⁻. Since R, the rocks, Kilimanjaro, Kilimanjaro⁻, and Kilimanjaro⁺ are all arbitrary for any situation in which parthood is indeterminate, (I) follows.⁷ (II) follows in exactly the same way, only replacing (5-26), (5-27), and (5-29) with the following claims:

(5-26*) Either the rocks and R compose Kilimanjaro, or they do not.

(5-27*) If the rocks and R compose Kilimanjaro, then some things compose both Kilimanjaro and Kilimanjaro⁺.

(5-29*) If the rocks and R do not compose Kilimanjaro, then some things compose both Kilimanjaro and Kilimanjaro⁻.

Let's now revisit the case for (III) and (IV). Here is one way to make the core intuition behind the argument as strong as possible: suppose that it is determinate that there are at most three material things. Suppose, too, that it is determinate that, x and y, exists, that $x \neq y$, and that both x and y are mereologically simple material things. It follows that it is determinate that there are at least two material things. Now, by (RN) and (K), it is clear that the following hold:

⁷Weatherson 2003 and Williams and Barnes forthcoming do not give the argument in this level of detail; for instance, they fail to explicitly appeal to (RN) and (K). Moreover, they never explain how from (5-31) holding determinately we are to conclude that (I) follows; Leibniz's Law is not explicitly appealed to, and the claim that it is indeterminate whether R is part of Kilimanjaro is never even explicitly appealed to in order to derive the relevant indeterminate identities. Nonetheless, I take it that the above reconstruction of the argument is what they have in mind.

(5-32) If it is determinate that nothing is composed of x and y , then it must be determinate that there are exactly two material things.

(5-33) If it is determinate that something is composed of x and y , then it must be determinate that there are exactly three material things.

So, the argument goes, it follows that:

(5-34) If it is indeterminate whether something is composed of x and y , then it must be indeterminate whether there are exactly two material things, as well as whether there are exactly three things.

Generalizing the argument for any situation in which there are finitely many things such that for some of them it is indeterminate whether they compose something, (III) and (IV) follow.

As I mentioned at the outset, my aim here will be to show that the possibility of external deviations undermines the alleged necessary connections between the relevant forms of indeterminacy in the mereological structure of the material world and the relevant forms of indeterminacy in its logical structure. Now the target is clear: I will argue that the possibility of external deviations allows for counterexample worlds for each of (I)-(IV), and exposes the flaws in the arguments for them. Let us now see how this works.

5.5 Indeterminacy in Mereological Structure without Indeterminacy in Logical Structure

Notice that since indeterminate parthood requires *de re* indeterminate composition, (I) follows from (II). And clearly (III) follows from (IV). So in order to show that all of these claims are false, it will be sufficient to give two counterexample worlds: one in which (I) is false, and one in which (III) is false. Now, since indeterminate identity requires indeterminate cardinality if there are only finitely many things, in order to get a world where (I) is false it will be sufficient to get a world with a determinate finite cardinality of material things where nonetheless for some pair of material things it is indeterminate whether one is part of the other. And in order to get a world where (III) is false, it will be sufficient to get a world with a determinate finite cardinality of material things, where for no pair of material things it is indeterminate whether one is identical to the other, but where nonetheless for some material things it is indeterminate whether there is something composed of them. Let's see how the possibility of external disparities allows us to construct such two worlds.

5.5.1 Against (I) and (II)

Let W_R be a world with material objects a , b , and c . Let's build some spatiotemporal structure into this world—assume that (i)-(iv) hold determinately at W_R :

- (i) Neither a 's exact location nor b 's exact location is a subregion of the other.
- (ii) a and b expand into c .

- (iii) Something is located somewhere only if it is a contraction of c .
- (iv) Something is a contraction of c only if it is identical to either a , b , or c .

Now let's assume that the following holds about the mereological structure of W_R :

- (R) It is indeterminate whether a is part of c and, as well as whether b is part of c .

From (i)-(iv) and (R) it follows that W_R is a world with a determinate finite cardinality of material things, but where parthood is indeterminate among some material things. Let's see why.

That parthood is indeterminate for some material things at W_R follows directly from (R): since it is indeterminate whether a is part of c and indeterminate whether b is part of c , there are pairs of material things such that it is indeterminate whether one is part of the other. Let's now see why W_R has a determinate finite cardinality of material things. First, from (i), (ii), and Leibniz's Law it follows that a , b , and c are pairwise non-identical: from (i) it follows that $a \neq b$, and from (ii) that $a \neq c \neq b$. Now since we are assuming that (i) and (ii) hold determinately at W_R , and since (RN) requires that Leibniz's Law also hold determinately at W_R , by (RN) and (K) it follows that a , b , and c are determinately pairwise non-identical. So it follows that it is determinate that there are at least three material things in W_R . On the other hand, (iii) and (iv) guarantee that it is determinate that a , b , and c are the only material inhabitants of W_R . For together with the assumption that material objects must be located somewhere, (iii) requires that every material object in W_R be exactly located at a subregion of c 's exact location, and (iv) requires that any such thing be a , b , or c . So since (iii) and (iv) hold determinately at W_R , it is determinate that a , b , and c are

the only material things in W_R . It follows, then, that it is determinate that there are exactly three material things at W_R .

W_R is thus a counterexample to both (I) and (II). It is world with indeterminate parthood and indeterminate *de re* composition, but with no indeterminate identity.

Here is the general thought behind W_R . The location relations between material things and regions of spacetime at this world are determinate, and so are the mereological relations among regions of spacetime. So the relative location relations among material things at this world are also determinate; this is what assuming that (i)-(iv) hold determinately at W_R amounts to. And from the determinacy of such relations it follows that the identity relations among material things are determinate as well. But the thought is that since the part-whole and relative location relations among material things need not align per the possibility of external deviations, it is possible that the former relations be determinate but that the latter be indeterminate.

A few points about W_R are worth noting. First, notice that W_R is not only a world where parthood is indeterminate and composition is *de re* indeterminate, but also a world where cardinality and identity are not indeterminate: per (5-25) it is also a world where existence is not indeterminate. So it is also a world with those two forms of indeterminacy in mereological indeterminacy, but with no form of indeterminacy in mereological structure: the overall logical structure of W_R is perfectly determinate.

Second, the following is the specific version of Contractions \Rightarrow Parts and Expansions \Rightarrow Fusions that are violated at W_R :

(Δ Contractions $\Rightarrow\Delta$ Parts)

It is determinate that x is a contraction of y only if it is determinate that x is part of y .

(Δ Expansions $\Rightarrow\Delta$ Fusions)

It is determinate that y is an expansion of the x s only if it is determinate that y is a fusion of the x s.

By (RN) and (K) it is clear that both Contractions \Rightarrow Parts and Expansions \Rightarrow Fusions also fail to hold determinately at W_R . One might worry, however, that R \Rightarrow P, Fundamentality, Distinctness and claims like (P1)-(P3) do not deliver the possibility of cases violating any of these claims. All they deliver are cases where a material thing is a contraction but not a part of another, and where some material things expand but do not compose others. But such cases have nothing to do with determinacy and indeterminacy. More generally, one might wonder whether violations of Δ Contractions $\Rightarrow\Delta$ Parts and Δ Expansions $\Rightarrow\Delta$ Fusions are metaphysically possible, and not merely logically consistent. The consistency of such cases is clear, given the consistency of (i)-(iv) and (R). But their metaphysical possibility is a different matter.

Two things about this. On the one hand, remember from the arguments for (I) and (II) that these claims allegedly hold as a matter of logic given certain principles of classical logic and classical extensional mereology: the thought was that given excluded middle and uniqueness of composition, indeterminate parthood and *de re* indeterminate composition *logically* require indeterminate identity. So a consistent description of a world like W_R is sufficient to undermine these claims as they have been defended in the literature, for nothing prevents that excluded middle or uniqueness of composition hold at W_R .

On the other hand, the worry about the metaphysical possibility of these cases cannot be that they involve indeterminate parthood and *de re* indeterminacy composition, for the possibility of these forms of mereological indeterminacy is precisely

what is at stake. So one must allow their possibility for the sake of argument, and object to them on the grounds that their possibility requires something unacceptable. However, once one accepts the metaphysical possibility of these forms of mereological indeterminacy for the sake of argument, it is easy to get the metaphysical possibility of cases violating $\Delta\text{Contractions} \Rightarrow \Delta\text{Parts}$ and $\Delta\text{Expansions} \Rightarrow \Delta\text{Fusions}$ from $R \Rightarrow P$, Fundamentality, Distinctness and appropriate assumptions about the contents of T^\square . This simply requires enriching L with the determinacy-that operator and making the following assumption in place of (P2):

(P4) It is possible that there be a pair of material things, such that it is indeterminate whether one is part of the other, and a pair of regions, such that it is determinate that one is a subregion of the other.

From $R \Rightarrow P$, Fundamentality, Distinctness, (P1) and (P4) it follows that there is a metaphysically possible world where a sentence of L claiming the following is true: for a pair of material things, x and y , it is determinate that x is exactly located at a subregion of the region at which y is exactly located, but indeterminate whether x is part of y .

Now, one may have another worry about the metaphysical possibility of W_R : perhaps it makes unjustified assumptions about what mereological principles are necessarily true. In particular, notice that W_R is a world where unrestricted composition fails; so W_R is not metaphysically possible if unrestricted composition is necessarily true. Prima facie, this sort of worry about W_R would be dialectically inappropriate, since, as I briefly mentioned earlier, the debate over indeterminacy in mereology is entangled with the debate over unrestricted composition. But one might point out

that the worry is dialectically inappropriate only in debates concerning *de dicto* indeterminate composition, whereas W_R concerns only indeterminate parthood and *de re* indeterminate composition. So the challenge for giving a counterexample world for (I) and (II) would be to give a world where parthood is indeterminate and composition is indeterminate, where there is no indeterminate identity, and where composition is unrestricted.

The challenge, however, can be met: W_R may easily be modified so that unrestricted composition holds without affecting our main result. Let W_R^* be a world like W_R , which differs from it in only two respects. First, $a + b$, $a + c$, $b + c$, and $a + b + c$ determinately exist in W_R^* along with a , b , and c (where $x_1 + \dots + x_n =_{df}$ the fusion of x_1, \dots, x_n). Second, (iv*) holds at W_R^* instead of (iv):

(iv*) Something is a contraction of c only if it is identical to either a , b , c , $a + b$, $a + c$, $b + c$, or $a + b + c$.

Like W_R , W_R^* is a world with a determinate finite cardinality of material things where composition is indeterminate, but where parthood is nonetheless indeterminate among some material things; so it is a counterexample to both (I) and (II) meeting the challenge. That parthood is indeterminate follows again from (R) alone. To see that W_R^* has a determinate finite cardinality of material things, notice that from Leibniz's Law, (i), (ii), and the fact that $a + b$, $a + c$, $b + c$, and $a + b + c$ exist in W_R^* , it follows there are at least seven material objects in W_R^* . So since Leibniz's Law, (i), (ii) and the fact that $a + b$, $a + c$, $b + c$, and $a + b + c$ exist in W_R^* , by (RN) and (K) it follows that it is determinate that there are at least seven material things in W_R . On the other hand, (iii) and (iv*) guarantee that there are no material things other

than the seven we already have; so by (RN) and (K) it follows that it is determinate that there are exactly seven material things at W_R^* . And it is clear that unrestricted composition holds at W_R^* : any material things compose something.

Thus, the possibility of external deviations allows for parthood to be indeterminate, for composition to be *de re* indeterminate, but for identity, existence, and cardinality not to be indeterminate. Where, then, do the arguments for (I) and (II) on the basis of (5-26)-(5-31) go wrong? The problem is not that they are not generalizable to all cases where parthood may be indeterminate—notice that at W_R and W_R^* there is not an object playing the role that Kilimanjaro⁻ plays in those arguments, *i.e.* an object that is composed of some things each of which is determinately part of a thing that has indeterminate parts. But notice that this is not at the cost of denying that unrestricted composition or some other mereological principle that in the Kilimanjaro example entails the existence of Kilimanjaro⁻. For as W_R^* makes clear, there may fail to be something playing the role of Kilimanjaro⁻ even if such principles hold.

5.5.2 Against (III) and (IV)

Let's move on to (III) and (IV). Consider a world, W_D , which is exactly like W_R except that the following assumption holds instead of (R):

(D) It is indeterminate whether there is something that a and b compose.

Now remember from W_R that from (i)-(iv) holding determinately it follows that it is determinate that there are exactly three material things, and so that identity is not indeterminate. From (D) it follows that composition is *de dicto* indeterminate. So are

(i)-(iv) and (D) sufficient guarantee that W_D is a world with a determinate finite cardinality of material things where identity is not indeterminate, but where composition is *de dicto* indeterminate, *i.e.* a counterexample world to (III) and (IV)?

No; for it is not clear that (D) is compatible with a , b , and c being the only material things in W_D . That is, it is not clear that (D) is in fact consistent with (iii)-(iv). The worry is that (D) makes it indeterminate whether there is a *fourth* material object in W_D , *i.e.* $a + b$: it seems that if there were a thing composed of a and b , then there would be an additional material object in W_D , and hence there would be at least four material objects in W_D . So one of (iv)-(vi) would have to fail. So it seems that (D) makes it indeterminate whether there are exactly three or exactly four material things in W_D .

However, we may dispel this worry and make it clear that (D) is compatible with (iii)-(iv) by building a bit more spatiotemporal structure into W_D . Let's assume that Fusions \Rightarrow Expansions and Uniqueness of Location hold at W_R , *i.e.* that it is determinate that some material things compose an object only if they expand into it, and that it is determinate that no two material things share their exact location. Let's look at what happens if these principles hold in W_D . If Fusions \Rightarrow Expansions holds in W_D , then a and b have a fusion, $a + b$, only if $a + b$ is an expansion of a and b . And so if Uniqueness of Location also holds in W_D , then a and b have a fusion, $a + b$, and expand into it only if $a + b$ is identical to such an object. But then the worry about an additional material object in W_D disappears provided both these principles hold in W_D : since a and b expand into c , if there were such thing as $a + b$, it would be identical to c , and hence it would not be a fourth object in W_D . Given, then, Fusions \Rightarrow Expansions and Uniqueness of Location, it is clear that (D) is compatible with a , b , and c being the

only inhabitants of W_D , even if it is indeterminate whether there is something composed of them. That is, given these principles, the apparent tension between (D) and (iii)-(iv) evaporates: despite (D), (iii) and (iv) together Fusions \Rightarrow Expansions and Uniqueness of Location effectively set a determinate upper bound on the cardinality of material things in W_D .

Here is the key idea more generally. Suppose that it is determinate that there are exactly n Fs, that it is determinate that there is at most one G, but that it is indeterminate whether there is a G. This seems to be inconsistent with it being determinate that there are exactly n things that are either F or G: it being indeterminate whether there is a G seems to make it indeterminate whether there are exactly n or exactly $n + 1$ things that are either F or G. But the apparent conflict disappears provided that it is determinate that every G is identical to one of the Fs: adding a G would make no difference in how many things there are that are either F or G. So the claims that there are exactly n Fs and that it is determinate that every G is identical to one of the Fs set a determinate upper bound on how many objects there are that are either F or G.

Thus, if both Fusions \Rightarrow Expansions and Uniqueness of Location hold at W_D , (D) is perfectly compatible with (i)-(iv). So it follows that there are exactly three material things at W_D , that identity is not indeterminate at W_D , but that composition is *de dicto* indeterminate at W_D . So we have a counterexample world to (III) and (IV).

One might have another sort of worry about W_D . Despite our discussion about indeterminate existence and (5-25), one may remain unconvinced that there is no indeterminate existence in W_D . And the worry is reasonable: after all, doesn't (D) just claim that it is indeterminate whether *there is* something composed of a and b?

What is giving the appearance that existence is indeterminate at W_D is that the indeterminacy-whether operator directly operates on an existentially quantified claim. But this does not require that existence be indeterminate. Suppose, for instance, that everyone but one person in the world has a head full of hair; the remaining person has lost quite a bit but is not yet completely hairless. Then it is determinate that there is at most one bald person, and also that it is indeterminate whether there is one. The latter claim is an indeterminate existence claim: $\nabla\exists x$ x is bald. But it does not require that existence be indeterminate. It only requires that it be indeterminate whether there exists a thing with certain features, *i.e.* being bald. And the indeterminacy may be blamed on the part of the claim concerning the relevant features—baldness in this example—not on the part that concerns there existing a thing satisfying such that so-and-so.

This is exactly what is going on in W_D : it is indeterminate whether there is something composed of a and b . But that does not require that existence be indeterminate: we may blame the indeterminacy on the part of the claim concerning composition, not on the one concerning existence. So from it being indeterminate whether there is something composed of a and b it does not follow that it is indeterminate whether there is something other than a , b , and c . All that follows from this is that it is indeterminate whether there is a thing with such-and-such features, *i.e.* being composed of a and b . But given Fusions \Rightarrow Expansions and Uniqueness of Location, it is clear that the existence of a thing with the relevant features would not require that there be something other than a , b , and c . So despite appearances to the contrary, there is no indeterminate existence in W_D , even if we were to bracket (5-25).

The idea behind W_D is thus similar to the idea behind W_R : location relations between material things and regions of spacetime are determinate, and that so are the mereological relations among regions of spacetime. So the relative location relations among material things at this world are also determinate. And from the determinacy of such relations it follows that the identity relations among material things determinate as well. But in this case principles determinately governing the behavior of relations of spatiotemporal location put a cap on the number of material things there are. This allows for relations of part-whole and relative location among material to align and misalign in appropriate ways for it to be possible that the latter relations be determinate but that the former be indeterminate.

One may have the same sorts of worries about W_D that we had about W_R , concerning metaphysical possibility *vs.* mere logical consistency. In this case, the principles violated are not only $\Delta\text{Contractions} \Rightarrow \Delta\text{Parts}$ and $\Delta\text{Expansions} \Rightarrow \Delta\text{Fusions}$, but also the following one:

$(\Delta\text{Expansions} \Rightarrow \Delta\text{Fusions}^*)$

It is determinate that the *x*s have an expansion only if it is determinate that the *x*s have a fusion.

But the worries may be answered just as before. Since one must allow for the sake of argument that it is possible that composition be *de dicto* indeterminate, we need just add a determinacy operator to L and replace (P2) with the assumption below in order to get the metaphysical possibility of violations of $\Delta\text{Expansions} \Rightarrow \Delta\text{Fusions}^*$:

(P5) It is possible that there be a pair of material things, such that it is indeterminate whether they compose something, and a pair of regions, such that it is determinate that they compose a region.

From $R \Rightarrow P$, Fundamentality, Distinctness, (P1) and (P5), the metaphysical possibility of the cases of external deviations at issue in W_D is metaphysically possible.

In the specific case of W_D , however, someone may worry that it is odd to think that $\Delta\text{Contractions} \Rightarrow \Delta\text{Parts}$, $\Delta\text{Expansions} \Rightarrow \Delta\text{Fusions}$, and $\Delta\text{Expansions} \Rightarrow \Delta\text{Fusions}^*$ are all violated, but that $\text{Fusions} \Rightarrow \text{Expansions}$ and Uniqueness of Location hold determinately. Moreover, one may worry that it is arbitrary to hand-pick the latter two claims as principles governing relations of relative spatiotemporal location in W_D , for they are just the appropriate ones to get the results we want. However, there is nothing odd or unprincipled about thinking that there are worlds where $\Delta\text{Contractions} \Rightarrow \Delta\text{Parts}$, $\Delta\text{Expansions} \Rightarrow \Delta\text{Fusions}$, and $\Delta\text{Expansions} \Rightarrow \Delta\text{Fusions}^*$ are all violated, but where $\text{Fusions} \Rightarrow \text{Expansions}$ and Uniqueness of Location hold determinately. For $R \Rightarrow P$, Fundamentality, Distinctness, and the relevant assumptions entail that there are such worlds. Surely these claims entail that there are worlds at which $\text{Fusions} \Rightarrow \text{Expansions}$ is violated, but also worlds where it holds—it is certainly not necessary that there be fusions that are not expansions! And with respect to Uniqueness of Location, remember that $R \Rightarrow P$, Fundamentality, Distinctness, and the relevant assumptions are neutral on whatever necessary truths there may be concerning relations of spatiotemporal location. So they are perfectly compatible with Uniqueness of Location being necessarily true—they do not deliver a world where it fails. On the other hand, even if Uniqueness of Location is not necessary, it is certainly not impossible: surely it is not necessary that no two things fail to share their exact location. So there is nothing strange or ad hoc about the alignments and misalignments there are at W_D .

Thus, the possibility of external deviations allows for composition to be *de dicto* indeterminate, but for identity, existence, and cardinality not to be indeterminate. Where, then, do the arguments for (III) and (IV) on the basis of claims such as (5-32)-(5-34) go wrong? In the case of W_D , the relevant claims are as follows:

(5-35) If it is determinate that nothing is composed of a and b, then it must be determinate that there are exactly three material things.

(5-36) If it is indeterminate whether something is composed of a and b, then it must be indeterminate whether there are exactly three material things.

(5-35) clearly follows from (RN) and (K) given (i)-(iv). And the thought was that we may move from (5-35) to (5-36). The problem is that this move seems to be valid but is in fact fallacious. As W_D makes clear, the move may be blocked simply by assuming that it is determinate that there is something that a and b compose only if such an object is one of the things that already exist. Moreover, notice that it is hard to think of a plausible set of principles governing the behavior of the determinate-that and indeterminate-whether operators that would allow us to make this jump; so that it cannot even be argued that W_R conflicts with some plausible principle governing the logic of determinacy and indeterminacy. For instance, it is clear that (RN) and (K) do not license the move. (RN) and (5-37) do license it, and so does (5-38) on its own:

(5-37) $\Delta(\phi \rightarrow \psi) \rightarrow (\Delta\psi \rightarrow \Delta\phi)$.

(5-38) $(\Delta\phi \rightarrow \Delta\psi) \rightarrow (\Delta\psi \rightarrow \Delta\phi)$.

But these two principles are clearly false. Surely it is determinate that Socrates is both human and not human only if Socrates is human, and so by (K) surely it is determinate

that Socrates is both human and not human only if it is determinate that Socrates is human. Moreover, it is determinate that Socrates is human. But from this you would not want to conclude that it is determinate that Socrates is both human and not human.

It follows, then, that there are counterexamples to all (I)-(IV) given the possibility of external deviations. Provided that the mereological and spatiotemporal structures of the material world may come apart, its mereological structure and its logical structure may also come apart, in such way that there may be indeterminacy in its mereological structure but not in its spatiotemporal or logical ones.

Let me finish this section by taking stock on an important point concerning the argument against mereological indeterminacy based on (5-1)-(5-5). Someone might grant that I have undermined (I)-(IV), and so that I have undermined that argument, but still worry about the dialectical payoff of this result. For one might think that we may give an argument in the same spirit along the following lines: there are worlds such that if parthood and composition among material things are indeterminate, then existence, identity, or cardinality among material things are also indeterminate. But at no world existence, identity, or cardinality among material things may be indeterminate; so at no world parthood and composition among material things may be indeterminate. The idea is then that while at strange worlds like W_R , W_R^* , and W_D indeterminacy in mereological structure does not lead to indeterminacy in logical structure, there are worlds at which it does, and that this is enough to rule out the possibility of mereological indeterminacy.

The same worry may be raised in another context. As I have mentioned a few times in this and last chapter, the claim that composition may not be *de dicto* indeter-

minate is a key premise of the argument from vagueness for unrestricted composition. Undermining (III) renders this premise unsupported. So if I have undermined (III) then I have given reasons for moderates about composition not to worry about the argument from vagueness, for it will no longer be worrisome if their views require that composition be *de dicto* indeterminate. However, someone might point out that while I may have shown that *some* moderate theorist about composition need not worry if her view requires *de dicto* indeterminate composition, I have not shown that no such theorist need worry about it; in particular, I have not shown that any of the usual moderate theorists (*e.g.* Van Inwagen 1990) need not be concerned. For it may still be that some (of the usual) moderate views require that composition be *de dicto* indeterminate in a way that leads to identity, existence, or cardinality being indeterminate.

Thus, the point is that while in some cases indeterminacy in the mereological structure of the material world may not lead to indeterminacy in its logical structure, in some cases it might; and that this is sufficient to reject that there may be indeterminacy in its mereological structure altogether. Two things about this. First, W_R , W_R^* , and W_D at least make it clear that mereological indeterminacy does not on its own require indeterminacy in logical structure: whether or not there is indeterminacy in logical structure at worlds where there is mereological indeterminacy depends on other features of those worlds, and on the interaction between those features and mereological indeterminacy. So it would be wrong to conclude that mereological indeterminacy is to be blamed for there being indeterminacy in logical structure: one may reject the other features or the problematic ways in which they interact with mereology. Another way to put the point: it need not be a *reductio* on mereological indeterminacy that there is indeterminacy in logical structure at some worlds where

there is indeterminacy in mereological structure, contrary to what the worry suggests. Second, notice that for all I have said it may be that all worlds where there is indeterminacy in parthood and composition are worlds that share the structural features that prevent mereological indeterminacy from requiring indeterminacy in identity, existence, or composition at W_R , W_R^* , and W_D . Remember that at these worlds relations of relative spatiotemporal location are determinate, and make matters of identity, existence, and cardinality among material things determinate. And there is a disconnect between mereological relations and relations of relative spatiotemporal location which allows for there to be indeterminacy in the former without indeterminacy in the latter, and hence without indeterminacy in identity, existence, and cardinality. So as long as at every world where there is mereological indeterminacy there are relations that play the role that relations of relative spatiotemporal location play in W_R , W_R^* , and W_D , at no world where there is mereological indeterminacy will there be indeterminacy in mereological structure. Of course, I have not defended this claim about every world where there is mereological indeterminacy. The point is only that the worry at issue may in principle be addressed with the kind of resources I have developed here.

5.6 Neutrality about the Nature and Source of Indeterminacy

I want to conclude this chapter by briefly noting that nothing in what I have argued here requires a particular view on the nature or source of indeterminacy—all the notions, principles, counterexamples worlds, etc. are in principle compatible with indeterminacy being an ontic, semantic, or epistemic phenomenon. As I mentioned at the outset, this is important: it allows us to undermine the sort of argument against mere-

ological indeterminacy based on (5-1)-(5-5) even if one thinks that all indeterminacy is semantic indeterminacy, and even if one thinks that no piece of logical vocabulary has precisifications.

It is easy to see that all the above is compatible with thinking that the indeterminacy at issue is ontic indeterminacy. This would mean, for instance, that for parthood and composition to be indeterminate is just for there to be no determinate matter of fact as to whether some material things stand in certain mereological relations to one another. Similarly, it would mean that (I)-(IV) claim that if there is no determinate matter of fact as to whether some material things stand in certain mereological relations to one another, then there must be no determinate matter of fact as to which material things are identical to which, as to what material things there are, and as to how many there are. My overall suggestion that indeterminacy in mereological structure does not require indeterminacy in logical structure would thus be construed as follows: there being no determinate matter of fact as to whether some material things stand in certain mereological relations to one another is compatible with there being determinate matters of fact about which material things are identical to which, about what material things there are, and about how many there are. And the core of my argument would be cashed out as follows: there failing to be determinate matters of fact about mereological relations among material things does not require that there be no determinate matters of fact about the relative spatiotemporal location among them. Because of these discrepancies, determinate matters of fact about the relative spatiotemporal location of material things may require determinacy in matters of fact about their identity, existence, and cardinality, even if matters of fact about mereological relations among them are indeterminate.

Similarly, all the above is compatible with thinking that the indeterminacy at stake is semantic in nature. This would mean that *e.g.* for parthood and composition to be indeterminate is just for certain sentences with mereological vocabulary to lack a determinate truth value, due to such vocabulary having multiple precisifications. Similarly, it would mean that (i)-(iv) claim that if certain sentences with mereological vocabulary lack a determinate truth value, then so must certain sentences with only logical vocabulary. My overall suggestion that indeterminacy in mereological structure does not require indeterminacy in logical structure would thus be that certain sentences with mereological vocabulary lacking a determinate truth value does not require that sentences with only logical vocabulary lack a determinate truth value. And the core of my argument would be construed as follows: certain sentences with mereological vocabulary lacking a determinate truth value do not require that sentences with location vocabulary also lack a determinate truth value. Because of this, sentences with location vocabulary having a determinate truth value may require that sentences with only logical vocabulary have a determinate truth value, even if sentences with mereological vocabulary lack a determinate truth value.

Finally, all the above is also compatible with thinking the indeterminacy at issue is epistemic indeterminacy. This would mean that *e.g.* for parthood and composition to be indeterminate is just for us to be ignorant as to whether certain mereological relations hold among material things. Similarly, it would mean that (i)-(iv) claim that if we are ignorant as to whether some material things stand in certain mereological relations to one another, then we must also be ignorant as to which material things are identical to which, as to what material things there are, and as to how many there are. My overall suggestion that indeterminacy in mereological structure does not require indeterminacy in logical structure would thus be cashed out as follows: being

ignorant as to whether some material things stand in certain mereological relations to one another does not require that we be ignorant as to which material things are identical to which, as to which material things there are, and as to how many there are. And the core of my argument would be cashed out as follows: being ignorant about mereological relations among material things does not require being ignorant about the relative spatiotemporal location relations among them. Because of these discrepancies, knowing about the relative spatiotemporal location relations among material things may require that we know about their identity, existence, and cardinality, even if we are ignorant about mereological relations among them.

BIBLIOGRAPHY

- Adams, Robert Merrihew. 1981. "Actualism and Thisness." *Synthese* 49:3–41.
- Armstrong, David Malet. 1989. *A Combinatorial Theory of Possibility*. New York: Cambridge University Press.
- . 1997. *A World of States of Affairs*. Cambridge: Cambridge University Press.
- Baker, Lynne Rudder. 2000. *Persons and Bodies*. Cambridge: Cambridge University Press.
- Bennett, Karen. 2006. "Proxy 'Actualism.'" *Philosophical Studies* 129(2):263–294.
- Brzozowski, Jacek. 2008. "On Locating Composite Objects." In Dean Zimmerman (ed.), *Oxford Studies in Metaphysics*, volume 4. Oxford: Oxford University Press.
- Cartwright, Richard. 1975. "Scattered Objects." In *Philosophical Essays*. Cambridge, MA: MIT Press.
- David Chalmers, David, Manley and Wasserman, Ryan (eds.). 2009. *Metametaphysics*. Oxford: Oxford University Press.
- DeRosset, Louis. 2009. "Production and Necessity." *Philosophical Review* 118:2:153–81.
- Doepke, Frederick. 1982. "Spatially Coinciding Objects." *Ratio* 24:45–60.
- Donnelly, Maureen. forthcoming. "Mereological Vagueness and Existential Vagueness." *Synthese* .
- Evans, Gareth. 1978. "Can There Be Vague Objects?" *Analysis* 38:208.

- Fine, Kit. 1994. "Ontological Dependence." *Proceedings of the Aristotelian Society* 95:265–90.
- . 2001. "The Question of Realism." *Philosopher's Imprint* 1.
- Frege, Gottlob. 1879. *Begriffsschrift*. In J. van Heijenoort (ed.), *From Frege to Gödel: A Source Book in Mathematical Logic, 1879–1931*, Cambridge, MA: Harvard University Press, 1967.
- Gibbins, Peter. 1982. "The Strange Modal Logic of Indeterminacy." *Logique et Analyse* 25:443–6.
- Hawthorne, John. 2006. "Three-Dimensionalism." In *Metaphysical Essays*. Oxford: Oxford University Press.
- Hawthorne, John (O'Leary-) and Cortens, Andrew. 1995. "Towards Ontological Nihilism." *Philosophical Studies* 79:143–65.
- Horgan, Terence and Potrč, Matjaž. 2000. "Bobjectivism and Indirect Correspondence." *Facta Philosophica* 2:249–70.
- Hudson, Hud. 2007. "The Lesser Kinds Quartet." *The Monist* 90:333–48.
- Koslicki, Kathrin. 2003. "The Crooked Path from Vagueness to Four-Dimensionalism." *Philosophical Studies* 114:107–34.
- Leonard, Henry S. and Goodman, Nelson. 1940. "The Calculus of Individuals and its Uses." *Journal of Symbolic Logic* 5:45–55.
- Leśniewski, Stanisław. 1916. "Foundations of the General Theory of Sets. I." In *Collected Works*, volume 1, 129–73. Dordrecht: Kluwer, 1992. Eng. trans. by D. I. Barnett.

- Lewis, David. 1986. *On the Plurality of Worlds*. Oxford: Basil Blackwell.
- . 1994. "Humean Supervenience Debugged." *Mind* 103:473–90.
- . 2001. "Truthmaking and Difference-Making." *Noûs* 35:4:602–15.
- Linsky, Bernard and Zalta, Edward N. 1994. "In Defense of the Simplest Quantified Modal Logic." In James Tomberlin (ed.), *Philosophical Perspectives 8: Logic and Language*, 431–58. Atascadero: Ridgeview.
- . 1996. "In Defense of the Contingently Nonconcrete." *Philosophical Studies* 84:283–94.
- Lowe, E. Jonathan. 2003. "Substantial Change and Spatiotemporal Coincidence." *Ratio* 16:140–60.
- . 2005. "Vagueness and Endurance." *Analysis* 65:104–12.
- Markosian, Ned. 1998. "Simples." *Australasian Journal of Philosophy* 76:213–26.
- . 2004. "Simples, Stuff, and Simple People." *The Monist* 87:405–28.
- McDaniel, Kris. 2003. "Against MaxCon Simples." *Australasian Journal of Philosophy* 81:265–75.
- . 2006. "Gunky Objects in a Simple World." *Philo* 9:47–54.
- . 2007a. "Brutal Simples." In Zimmerman (2007).
- . 2007b. "Extended Simples." *Philosophical Studies* 133:131–41.
- Menzel, Christopher. 1990. "Actualism, Ontological Commitment, and Possible Worlds Semantics." *Synthese* 85:355–89.

- Miller, Kristie. 2005. "Blocking the Path from Vagueness to Four Dimensionalism." *Ratio* 18:317–31.
- Parsons, Josh. 2000. "Must a Four-dimensionalist Believe in Temporal Parts?" *The Monist* 83:399–418.
- . 2004. "Distributional Properties." In Frank Jackson and Graham Priest (eds.), *Lewisian Themes*. Oxford: Oxford University Press.
- . 2007. "Theories of Location." In Zimmerman (2007).
- . MS. "Entension, Or How It Could Happen That an Object Is Wholly Located in Each of Many Places."
- Pelletier, Francis Jeffry. 1984. "The not-so Strange Modal Logic of Indeterminacy." *Logique et Analyse* 27:481–92.
- . 1989. "Another Argument Against Vague Objects." *Journal of Philosophy* 86:481–492.
- Plantinga, Alvin. 1974. *The Nature of Necessity*. Oxford: Oxford University Press.
- Prior, Arthur Norman. 1957. *Time and Modality*. Oxford: Clarendon.
- Rosen, Gideon. MS. "Metaphysical Dependence: Grounding and Reduction." .
- Saucedo, Raul. forthcoming. "Parthood and Location." In Zimmerman (2010).
- Schaffer, Jonathan. 2009. "On What Grounds What." In David Chalmers and Wasserman (2009), 347–83.
- . MSa. "Grounding as the Primitive Concept of Metaphysical Structure." .
- . MSb. "Spacetime the One Substance."

- Sider, Theodore. 1997. "Four-Dimensionalism." *Philosophical Review* 106:197–231.
- . 2000. "Simply Possible." *Philosophy and Phenomenological Research* 60:585–90.
- . 2001. *Four-Dimensionalism*. Oxford: Clarendon.
- . 2003. "Against Vague Existence." *Philosophical Studies* 114:135–46.
- . 2005. "Another Look at Armstrong's Combinatorialism." *Noûs* 39:679–95.
- . 2007. "Parthood." *Philosophical Review* 116:51–91.
- . 2009. "Ontological Realism." In David Chalmers and Wasserman (2009).
- . MS. *Writing the Book of the World*.
- Simons, Peter. 1987. *Parts: A Study in Ontology*.
- Smith, Nicholas J.J. 2005. "A Plea For Things That Are Not Quite All There: Or, Is There a Problem about Vague Composition and Vague Existence?" *Journal of Philosophy* 102:381–421.
- Tarski, Alfred. 1929. "Foundations of the Geometry of Solids." In *Logics, Semantics, Metamathematics. Papers from 1923 to 1938*, 24–29. Oxford: Clarendon, 1956. Eng. trans. by J. H. Woodger.
- Uzquiano, Gabriel. forthcoming. "Mereological Harmony." In Zimmerman (2010).
- van Inwagen, Peter. 1981. "The Doctrine of Arbitrary Undetached Parts." *Pacific Philosophical Quarterly* 62:123–37.
- . 1990. *Material Beings*. Ithaca, NY: Cornell University Press.
- Varzi, Achille. 2007. "Promiscuous Endurantism." *American Philosophical Quarterly* 44:181–9.

- Wasserman, Ryan. 2002. "The Standard Objection to the Standard Account." *Philosophical Studies* 111:197–216.
- Weatherson, Brian. 2003. "Many Many Problems." *Philosophical Quarterly* 53:481–501.
- Williams, J. Robert G. 2008. "Working parts: reply to Mellor." In Robin LePoidevin (ed.), *Being: Contemporary Developments in Metaphysics*. Cambridge: Cambridge University Press.
- Williams, Robert and Barnes, Elizabeth. forthcoming. "Vague Parts and Vague Identity." *Pacific Philosophical Quarterly*.
- Williamson, Timothy. 1998. "Bare Possibilia." *Erkenntnis* 48:257–73.
- . 1999. "Existence and Contingency." *The Aristotelian Society: Supplementary Volume* 73:181–203.
- Zimmerman, Dean (ed.). 2007. *Oxford Studies in Metaphysics*, volume 3. Oxford: Oxford University Press.
- . 2010. *Oxford Studies in Metaphysics*, volume 6. Oxford: Oxford University Press.