Weak Location

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Abstract

Recently, many philosophers have been interested in using locative relations to clarify and pursue debates in the metaphysics of material objects. Most begin with the relation of exact location. But what if we begin instead with the relation known as weak location – the relation an object x bears to any region not completely bereft of x? I explore some of the consequences of pursuing this route for issues including *coincidence*, *extended simples*, and *endurance*, with an eye to evaluating the prospects for taking weak location as our fundamental locative relation.

1 Weak Location

Aristotle introduces the topic of location in *Physics* IV.3 by noting that 'the most basic way of all' in which 'one thing is said to be *in* another' is 'as a thing is in a vessel and, generally, in a place' (Hussey, 1993: 210^{a}14–24, p. 24). There is a lot to be said about Aristotle's views on place (Morison, 2002). My principal interest concerns the most basic relation of location between things and places that Aristotle here introduces, *being in*.

The examples of the derivative uses of 'is in' he gives ('as the finger is in the hand', 'as man is in animal, and, generally, form in genus') suggest that this is most basic use of 'is in' does not make use of the locative relation that has been the focus of considerable recent metaphysical theorising, the relation of

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exact location (or *exact occupation*).[1] Rather, Aristotle is proposing that we should take a weaker locative relation as basic.[2]

Aristotle's examples omit some of the ways in which we say one thing is in another. For example, suppose we are playing a game of *Battleship*. It is natural to say that when you get a 'hit' on a grid reference, you have identified a square that one of my ships is in, because it can be found there even though it is not contained in that single square. This suggests that the most natural relation in the vicinity of Aristotle's discussion is the relation of *weak location*. Josh Parsons offers this gloss:

> I am weakly located in my office iff I am in my office in the weakest possible sense: iff my office is not completely free of me. I should count as weakly located in my office when I am sitting at my desk, when I am reaching an arm out of the window, or when I am reaching an arm in the window from the street outside. (Parsons, 2007: 203)

I think this is, more or less, the relation between things and places expressed by the ordinary English locative phrase 'is in'. For most questions of the form 'Where is X?' are answered by citing a weak location of X:

(1) a. Where is the pasta?
    b. (In) Aisle 7.

(2) a. Where is Sylvester?
    b. He's in the kids' room.

Apart from Parsons, however, there has been relatively little attention paid to this broadly Aristotelian proposal that weak location is the most basic locative relation. Parsons' own treatment is idiosyncratic, because he wraps his discussion of weak location up with his commitment to its interdefinability with other locative relations. My aim in the present paper is to explore this neglected option.

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[1] An incomplete list of those who have been involved in what Costa (2017) dubs 'the locative turn': Balashov (2010); Calosi (2014); Casati and Varzi (1999); Donnelly (2011); Eagle (2010; 2016a); Eddon (2010); Gilmore (2008; 2018); Hudson (2006); van Inwagen (1990); Kleinschmidt (2011); Leonard (2014; 2016); Lewis (2002); McDaniel (2007); Parsons (2007); Saucedo (2011); Sider (2007).

[2] To the extent that Aristotle is interested in exact location, it is tied up with his notion of a *primary place*, not with the locative relation itself.

I do not propose to argue that weak location is the fundamental locative relation. Rather, I offer this paper in the service of evaluating that hypothesis in terms of its consequences. There are a number of recent debates in the metaphysics of material objects in which locative ideology has figured prominently (around extended simples, coincidence, and endurance). These discussions look quite different if weak location is the fundamental locative relation used to frame and characterise the positions in these debates. Some of these differences and their consequences may be welcome, some unwelcome, but we need to know what they are to compare our hypothesis with the orthodox approach (i.e., taking exact location as fundamental). So I think of this paper as a contribution to 'measuring the price' of the hypothesis that weak location is fundamental (Lewis, 1983: x).

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The plan for this paper is as follows. After introducing some background assumptions and definitions in section 2, I will turn in section 3 to the question of the possible patterns of instantiation of weak location, drawing here on the basic idea that fundamental relations are recombinable. The broadly combinatorial principle of redistribution I draw on has some consequences about coincidence, which are explored somewhat tentatively in section 4. I briefly address the much-discussed principle of *mereological harmony* in section 5, before examining the consequences of treating weak location as fundamental for those ongoing debates in the metaphysics of material objects which can be framed locatively: debates over extended simples (section 6) and endurance (section 7). I turn briefly to the question of how weak location relates to exact location in section 8. I conclude with some thoughts on whether the costs we have identified are worth paying.

2 Defining Other Locative Relations

Orthodox (or dualist) substantivalism is the view that both material objects and regions of spacetime are fundamental existents, and neither is to be reduced to the other.[3] There will only be a fundamental locative relation if

[3]It is thus neither relationalist (Nerlich, 1976: 6–8) nor supersubstantivalist (Schaffer, 2009 and Sider, 2001: 110–3).

we assume something like this, because we will need some relation to characterise the connection between these fundamental entities. Accordingly, I assume substantivalism as a precondition of our target hypothesis. Various commitments naturally accompany orthodox substantivalism:[4]

If weak location is fundamental, it will not be introduced by explicit definition. It may be indirectly characterised by its connections with existing ordinary locative expressions:

Weak location Weak location ($@_\circ$) is the unique relation between material objects and regions satisfying the following constraints (perhaps among others):

- Weak location holds between an object and any region not entirely free – or completely bereft – of the object (as Parsons' glossed it above);
- Whenever an object can be found in a region, even if not wholly within it, it is weakly located there;
- Whenever an object is contained within R, it is also weakly located in R, and in every region including R;
- Whenever an object is restricted (or confined) to R, it is not weakly located in any region not overlapping R;
- Whenever an object fills R, it is also weakly located in R and every region overlapping R.

Assuming this description suffices to help us glom onto the relation in question, we can use it to define some other locative relations of interest. Specifically, we should be able to give explications of the notions of *filling*, *containment*, etc., that will show that weak location satisfies the initial observations used to characterise it.[5]

[4]They are not uncontroversial in themselves, but I think they are uncontroversial given orthodox substantivalism; they are no more controversial than it. E.g., that being a region excludes being a material object; that regions only have regions as parts and only compose regions; that material objects only have material objects as parts and only compose material objects, that any location relation holds only between material objects and regions, perhaps among others. I will mostly keep these trivial commitments implicit for readability.

[5]I note a potential limitation of the present discussion: the weak location relation characterised by the above gloss is a two-place relation between things and regions of spacetime. Considerations of length preclude my considering other explications of 'is in', such as temporary weak location (a 3-place relation between things, regions of space, and times). I do

We will make use of some mereological notions in constructing these definitions. To be more explicit about the background mereology, I assume that we have the mereological relations of (improper) parthood (symbolised '$\sqsubseteq$') and overlap ('$\circ$') and that these obey at least the axioms of *Minimal Extensional Mereology* (Simons, 1987: 25–31). These axioms state that 'x is part of y' is a partial order; that if x is a part of y and distinct from y, then there is part of y that doesn't overlap x (*Weak Supplementation*); and that if there is a common part between two things, there exists a *Maximal Common Part*. Minimal Extensional Mereology lacks the principle of *Unrestricted Composition*, that given any things, there exists a fusion of those things.[6] If this further principle is added to MEM, we obtain the full strength of *Classical Extensional Mereology*. I assume that parthood is a generic relation, among the species of which are both the *material part* relation between material objects, and the *subregion* relation between regions.

With this background, I adapt some definitions of other locative relations from Parsons (2007) and Eagle (2016a: §2). I assume for simplicity that everything implicitly quantified over in these definitions is weakly located in spacetime. Throughout, the expression *is in* denotes weak location, symbolised $@_\circ$.

Definition 1 (Some locative relations).

- x *fills* (or *pervades*) R iff x is in every region overlapping R. In symbols:

$$x \mathbin{@_{\geqslant}} R \equiv_{\text{df}} \forall S(S \circ R \to x \mathbin{@_\circ} S).$$

- x is *contained in* (or *is wholly within*) R iff every part of x is in R:

$$x \mathbin{@_{\leqslant}} R \equiv_{\text{df}} \forall y(y \sqsubseteq x \to y \mathbin{@_\circ} R).$$

- x is *wholly located at* R iff x both fills and is contained in R:

$$x \mathbin{@_{\approx}} R \equiv_{\text{df}} x \mathbin{@_{\geqslant}} R \land x \mathbin{@_{\leqslant}} R.$$

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note here that consideration of the fundamentality of spacetime regions (and the consequent derivativeness of spaces and times), given relativistic physics, seems to me to justify thinking that a fundamental locative relation will have spacetime regions as one relata – but length again precludes an extensive argument for this.

[6] Fusion is defined in the usual way: x fuses some things, the Ys, iff x overlaps all the Ys and only overlaps things which overlap the Ys.

- x is *confined to* (or *is entirely located in*) R iff x is in R, and every region it is in overlaps R:

$$x \mathbin{@_{\ll}} R \equiv_{\mathrm{df}} x \mathbin{@_{\circ}} R \wedge \forall S(x \mathbin{@_{\circ}} S \rightarrow S \circ R).$$

- x is *perfectly located* at R iff x fills and is confined to R:[7]

$$x \mathbin{@_{=}} R \equiv_{\mathrm{df}} x \mathbin{@_{\geqslant}} R \wedge x \mathbin{@_{\ll}} R.$$

Some of the relations explicitly defined above have close parallels in English. The relation of filling is very close to what is expressed by the ordinary English term *filling* (at least in our more pedantic moments). Similarly for containment and *contained in* and confinement and *confined to*. These definitions aim to explicate some of our existing locative terminology. Others, such as the different varieties of whole and perfect location, introduce new technical terms that do not behave necessarily in the same way as the ordinary English *is located at*. All are to be understood from now on as stipulated by the foregoing definition, though the terminological choices are reasonable ones, and (as is obvious by inspection) vindicates the near-platitudes we used to characterise the weak location role in section 2. For example, it is very natural to think that an object x fills a region R, in the ordinary sense, just when $x \mathbin{@_{\geqslant}} R$ – when x is in every part of R.[8]

The distinction between *contained in* and *confined to* is only significant if an object can have all of its parts weakly located in each of two disjoint regions (Parsons, 2007: 212–3). In that case the object is contained in each but confined to neither. It follows immediately from the definitions that, in such a scenario, an object may have at least two whole locations, and we may well regard it as multiply located according to that scenario. But any located object has at most one perfect location (Parsons, 2007: Appendix and Simons,

[7] One important terminological point. What I have called *perfect location* is what Parsons (2007: 203–5) calls 'exact location'. A different name seems appropriate, since this is not the same relation that most participants in the literature call 'exact location' – for example, Balashov (2010: 16), Gilmore (2018: §2), and Hudson (2006: 98).

[8] Perhaps ordinary objects are, as Eddington (1928: ix–x) maintained, 'nearly all empty space', and thus fill only a scattered portion of the region they appear to enclose. Still, we take that to be a discovery about the unusual nature of ordinary objects, not a reason to think that an object can fill a region it is not in. Of course, we needn't agree with Eddington that objects are not weakly located in those supposedly 'empty' regions that they have overwhelming influence over.

1987: 30), whether it has multiple whole locations or not. But if an object has just one region at which it is wholly located, it is also perfectly located at that same region.

3 Recombination and Redistribution of Weak Location

With these definitions in hand, what follows from our assumption that weak location is the fundamental locative relation? Many philosophers have thought that the significance of this observation stems from the fact that fundamental relations can have their instances permuted to generate new possibilities:

Recombination 'any pattern of instantiation of a fundamental relation [is] possible' (Sider, 2007: 52). (See also Armstrong, 1989a.)

This formulation is more aspirational than precise. We don't yet know, for example, what a 'pattern of instantiation' is. Does '$Rab \wedge \neg Rab$' state a pattern of instantiation of some fundamental relation R? Presumably not, since is not in fact possible, so would be a counterexample to Recombination if it were. But why not?

With respect to weak location, the following should presumably *not* be acceptable patterns of instantiation of weak location:[9]

- Where R and S are regions, x and y objects, neither 'R @$_\circ$ S' nor 'x @$_\circ$ y' describes an acceptable pattern of instantiating weak location (wrong relata);
- Where R is a region that is part of a region R^+, and x an object, 'x @$_\circ$ $R \wedge \neg x$ @$_\circ$ R^+' does not describe an acceptable pattern of instantiating weak location – it violates the truism from section 2 that if something is in a region R, it is also in every region including R.
- Where R is a region and x an object, 'x @$_\circ$ $R \wedge \neg\exists y(y \sqsubset x \wedge y$ @$_\circ$ $R)$' does not describe an acceptable pattern of instantiating weak location – this violates a consequence of the truism from section 2 that if an object is confined to the complement of R, it is not weakly located in R. (Here '$\sqsubset$' represents proper parthood.)

[9] I thank a referee for suggesting that I be more explicit at this point.

And presumably there are many more sentences formulated using mereological and locative relations that are logically consistent and yet don't describe coherent patterns of instantiation of location and parthood, when those predicates have their intended interpretation.

I don't pretend to have anything like a full characterisation of which patterns of instantiation are appropriately in the range of the quantifier 'any' in Recombination. What I will offer instead is a weaker principle, conforming to the spirit of Recombination, which states that a class of ways of recombining actual objects and locations always yields a possibility. The motivating idea is that *redistributing* objects over regions of spacetime is always possible. Let me now make this precise.

Let X be some set of non-overlapping (disjoint) material objects, and let $\mathfrak{R}$ be some set of non-overlapping spacetime regions. A *distribution* λ is a function from X into the powerset $\wp\mathfrak{R}$. So a distribution is a function from disjoint material objects to sets of disjoint regions in $\mathfrak{R}$. The combinatorial principle about location I endorse is this: for any distribution, it is possible for any object in its domain to be weakly located at those regions it is mapped to by the distribution. (It may be weakly located at other regions as well, including some not in the set $\mathfrak{R}$ – but it is at least possible that it be located at all the regions in the subset of $\mathfrak{R}$ it is distributed to). That is:

Redistribution If λ is a distribution of the disjoint members of X to subsets of the set of disjoint regions $\mathfrak{R}$, then there is a possible situation in which the pattern of instantiation of weak location is partly described by the following:

$$\forall x \in X \; \forall R \in \mathfrak{R} \; \left(R \in \lambda(x) \rightarrow x \; @_{\circ} \; R\right).$$

Redistribution as formulated does not entail the possibility of any of the problematic scenarios from earlier that unrestricted recombination might seem to give rise to. (It doesn't rule them impossible, but being generatable by redistribution is not a necessary condition on combinatorial possibility.) Nor does it entail that any scenario with the same distribution is possible. For example, a scenario where some things are distributed over some regions and in which *in addition* we alter the mereological relations among members in X, so that they are no longer disjoint in that scenario, may not be possible. All that Redistribution entails is that for each distribution of disjoint things to disjoint regions, there is at least one possibility in which that distribution maps things to regions all of which are among their weak locations.

The descriptions that Redistribution says are possibly true are not complete descriptions of a pattern of instantiation of weak location. We need to supplement the distribution with other principles to fill in those missing details about what is weakly located where that Redistribution doesn't supply on its own. Such further principles might include the following:

Inheritance Necessarily, if something is in a region R, anything it's part of is also in that region. That is:

$$\Box\forall x\forall R\,(x \mathbin{@_\circ} R \to \forall y(x \sqsubseteq y \to y \mathbin{@_\circ} R))\,.$$

R-Inheritance Necessarily, if something is in a region R, it is also in every region including R. That is:

$$\Box\forall x\forall R\,(x \mathbin{@_\circ} R \to \forall S(R \sqsubseteq S \to x \mathbin{@_\circ} S))\,.$$

Delegation 'A complex entity can't be weakly located at a certain region unless one of its proper parts – a 'delegate' – is weakly located at that region as well' (Gilmore, 2018: §3). That is:

$$\Box\forall x\forall R\,(\exists y\; y \sqsubset x \to (x \mathbin{@_\circ} R \to \exists z(z \sqsubset x \land z \mathbin{@_\circ} R)))\,.$$

R-Delegation Nothing can be in a complex region without being in a proper part of it. That is:

$$\Box\forall x\forall R\,(\exists S\; S \sqsubset R \to (x \mathbin{@_\circ} R \to \exists T(T \sqsubset R \land x \mathbin{@_\circ} T)))\,.$$

There may well be others. These principles help us to get from the fact that a certain distribution of weak locations of disjoint objects to disjoint regions is possible to a complete description of a locative possibility. But in our argument below we generally won't need a complete description of a possibility; we will only need the possibility of a certain distribution, given some domain of disjoint objects and a partition of the spacetime.

In many cases, however, while the description Redistribution entails to be possible doesn't itself specify every locative fact about a possibility, it is nevertheless intuitively complete. This occurs in cases where the locative facts *supervene* on the distribution. If we have for example a domain of in which every object either is or is a fusion of fundamental mereologically simple objects, and a spacetime in which every region either is or is a fusion of spacetime points, then the distribution which maps each simple object to a set of spacetime points at which it is weakly located will suffice to fix, given R-Inheritance and R-Delegation, which regions each simple is (weakly located) in, and then by Inheritance and Delegation, in which regions every object is weakly located in. These sorts of cases will be important below. However, we will also consider cases (esp. in section 5) in which the spacetime doesn't fundamentally consist of mereologically simple spacetime points, and cases in which the domain of material objects doesn't contain only objects that fuse only mereological simples. In these cases, and others, a distribution of simples to points will not fix all the locative facts.

4 Recombination and Coincidence

Saucedo (2011) uses recombination of *exact location* in an ingenious way, to generate some very exotic mereo-locative possibilities. Say that a material object x is a *proper contraction* of material object y iff x's exact location is a proper subregion of y's exact location. Using this definition, and the recombinatorial consequences of the fact that (in his framework) exact location and parthood are distinct and yet both fundamental relations, Saucedo (2011: 275–81) discusses two quite unusual possibilities that arise from recombination (even when suitably restricted):

1. *crowded simples*, objects which have no parts, but which do have proper contractions (all crowded simples are extended simples, but not *vice versa*); and

2. *compact fusions*, which have parts, but no proper contractions.

If we admit that crowded simples are possible, we get truly strange cases of coincident objects: a plenitude of objects, made of distinct hunks of the same kind of matter, all coinciding in the region they occupy. It is not at all clear how the kinds of matter with which we are familiar could permit this 'multiple occupancy' – the fact that a given region is already occupied by a given material object is generally taken to exclude other material objects, made of distinct matter, from also coming to occupy that region. This is coincidence of a most unusual sort, not previously countenanced by philosophers – not like statue/clay cases, where distinct objects made of the same matter share a location, and not like cases of interpenetration, where distinct objects made of different non-interacting kinds of matter – ordinary matter and ghostly ectoplasm, for example – share a location. This kind of coincidence will strike many as implausible.

Return now to our framework, rather than Saucedo's, in which weak location is the fundamental relation, and Redistribution is the basic combinatorial principle in use. We do not immediately get Saucedo's unusual entities. We cannot make use of his notion of a proper contraction, defined as it is in terms of exact location. We must introduce an analogous notion by defining it using weak location. Here is a suggestion:

Definition 2 (Contraction*). x is a *contraction** of y iff every region in which x can be found is also a region in which y can be found:

$$x \trianglelefteq y =_{\text{df}} \forall R(x \,@_\circ\, R \to y \,@_\circ\, R).$$

x is a *proper contraction** of y iff $x \trianglelefteq y \land \neg y \trianglelefteq x$.

It follows from our definitions that $x \trianglelefteq y$ iff the perfect location of x is a (possibly improper) subregion of the perfect location of y (assuming for now that both x and y have perfect locations). The notion of perfect location is a useful proxy in our setup for the notion of exact location (indeed, it is the relation Parsons calls 'exact location'). So our definition of contraction* is a reasonable one, since it is equivalent to Saucedo's definition with perfect location substituted for his use of exact location. (Whether these really do amount to the same thing I return to in section 8.)

If x is an improper contraction* of y (i.e., y is also a contraction* of x), then x and y *weakly coincide*: they have all the same weak locations. So we might with justice have called contraction* the relation of *subcoincidence*. So the question of whether objects stand in the relation of contraction* is bound up with the question of whether weak coincidence is possible.

Certain cases of weak coincidence do follow from Redistribution. Suppose we consider two distinct mereological simples, a and b. Consider a spacetime in which all regions are fusions of spacetime points, and the set of regions $\mathfrak{R}$ just be those points. There is a distribution which maps a and b to the same subset of $\mathfrak{R}$, and Redistribution then entails that a and b are weakly located at exactly the same regions, and thus coincide in their perfect location. Likewise, if a distribution maps a to some set of points A, and maps b to a subset of A, that will yield, by Redistribution, a possibility in which b is a contraction* of

a. Since in this scenario a is simple, it is the equivalent in our framework of Saucedo's crowded simples.

But things don't end up looking exactly as they do in Saucedo's paper. Saucedo himself considers compact fusions that require arbitrary recombination of the locative features of objects and their parts:

> Compact fusions may thus be arbitrarily small; their location may even be a mereologically 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. (Saucedo, 2011: 279)

The possibility of such cases does not follow from Redistribution, and there are good reasons to think they are not possible. If an object is a proper contraction* of one of its proper parts, then (*per impossibile*) the object is not weakly located in a region which part of it is in. This would violate the intuitive characterisation of weak location, and more specifically would be in conflict with Inheritance. So we were right in our formulation of Redistribution to focus on the distribution of the weak location of disjoint things, and letting the weak locations of composite objects be fixed by the weak locations of their parts. Even so, free Redistribution of distinct simples does permit arbitrary coincidence of simples.

If s is a crowded simple, there is an object which is only in regions s is in, but which is not part of s. So what motivates crowded simples is just this thought: recombination of weak location *already* shows subcoincidence in weak location to be possible. If so, crowded simples emerge as the by-product of arbitrary subcoincidence in weak location, and are not in themselves of particular interest. Again, there would be a compact fusion if there were a composite object which is wholly located at a mereologically simple region. It would accordingly need to be contained in that region, so that every part of it is in one and the same simple region. For this to be possible already *presupposes* the possibility of coincidence in weak location between the mereologically disjoint parts of this object. It is arbitrary coincidence, generated by Redistribution, which is responsible for the possibility of these unusual entities.

We may wish to take the simplicity and intuitive plausibility of Redistribution to show that such weak (sub)coincidence is possible. Alternatively, we may wish to restrict Redistribution in such a way as to avoid these sorts of cases. Many philosophers who have thought about location and mereology in a dualist framework have assumed anti-coincidence (Eagle, 2010; Gilmore, 2007), and so must implicitly assume some restriction on recombination of whatever their fundamental locative relations are. Unfortunately, these authors haven't offered much of an argument for anti-coincidence. Those who accept *supersubstantivalism* can appeal to a pretty good anti-coincidence argument: exact location is identity, coincidence involves co-location without identity, contradiction. But there is no argument like that which explains, for the dualist substantivalist, why we should ban those distributions which lead to weak coincidence or subcoincidence. Any purported restriction on Redistribution will not be principled, but brute (Dorr, 2008: 53). And many philosophers have concerns about accepting such brute restrictions on possibility that do not derive from either logic or analytic truisms about the notions in question (Skow, 2007: 116). Moreover, I know of no principled restriction on Redistribution that would prohibit coincidence, while nevertheless being able to generate sufficiently many possibilities of interest. It will emerge in our discussion in the following sections that one reason for adopting Redistribution as stated is that it is both simple and strong, generating many possibilities worthy of serious consideration.

If we are considering distributions of simple objects to points, there is a somewhat natural restriction that avoids coincidence: to require that all distributions have a function as their converse relation (this will be the 'is occupied by' function). It is more difficult to formulate a plausible restriction on Redistribution more generally, where we may be considering distributions of any collection of possibly complex objects over any partition of the spacetime, and I do not have any proposed restriction to offer here.

4.1 Motivating Weak Coincidence

I wish to conclude this section by gesturing at some considerations that might make someone who took weak location as fundamental potentially willing to countenance weak coincidence.

One kind of case that has motivated people to begin with weak location, rather than exact location, are objects which seem to lack any exact location. Perhaps the imprecisely located objects of quantum mechanics provide an example (Pashby, 2016; Simons, 2004). Maybe ontic vagueness (specifically, objects such that it is indeterminate which things are part of them) might provide cases where it can be argued the lack of a determinate exact location entails that there is no exact location at all. Some have argued recently that the Stoic notion of a blend provides a case of location without exact location (Leonard, 2014; Nolan, 2006).

In standard treatments of these cases, while there is no exact location for the objects in question, they are still in space – they still have some weak locations. It might even be that their weak locations suffice to characterise all that we can locatively say about an object. I can imagine being attracted to the view that an imprecisely located quantum object, not in an eigenstate of position, is weakly located at all and only those regions at which it has a non-zero chance of being found on measurement of position.

Focussing on that case, imagine two simple quantum particles that are each confined to some opaque box, but are moving around within the box in such a way that they each have some chance of being found anywhere within the box when it is opened. Their wave function is 'spread out' over the whole region bounded by the box. We can then say: these objects now have no exact location, but are instead weakly located throughout the box. (They may come to have an exact location on measurement, but not yet.) These objects then weakly coincide. But they may not have an objectionable form of coincidence: we can consistently add to our scenario the claim that the two objects have zero probability of being localised to the same region on measurement. They each have some chance of being found anywhere in the box, but no chance of being found together, so they won't end up interpenetrating one another. So here we have weak coincidence, motivated by some empirical considerations. And if there is one case of weak coincidence, then it cannot be an insuperable objection to Redistribution that it entails the possibility of just this pattern of weak coincidence, as well as other examples.

These observations are not conclusive. But there is still some reason here for friends of weak location to think that certain kinds of cases of coincidence should be possible, when they arise for inexactly located things that weak location is well-placed to handle. From those cases, an indirect case of Redistribution is that it is the recombinatorial principle which best balances simplicity and strength.

5 Perfectness, Gunk, Junk, and Harmony

We just considered a couple of cases where objects might appear to lack exact locations. But if there is any pattern of weak location for an object, even if if is inexactly located, nevertheless it seems that it will be perfectly located at some precise region – the intersection of every region that it is confined to. That gives us this principle:

Perfectness Necessarily, everything that is weakly located somewhere has a perfect location:[10]

$$\Box\forall x(\exists R(x\ @_{\circ}\ R) \rightarrow \exists S(x\ @_{=}\ S)).$$

Uzquiano (2011: 215-6) has shown that if (i) there are mereologically atomic regions of space, and (ii) the mereology governing regions of space is CEM, then Perfectness holds. In effect, Uzquiano's result is that Perfectness holds in any spacetime in which the description 'the intersection of the regions to which x is confined' always denotes a region, and if we trace through the definitions, that region will turn out to be the perfect location of x.

This result has some significance for us. If Perfectness holds, then we could equally well have taken perfect location to be the fundamental relation (as Parsons does), because we can define weak location in terms of perfect location. (Like so: x is weakly located at R just in case x is perfectly located at S and S overlaps R.) Since either relation taken as primitive gives us the resources to define the other, some awkwardness faces us. Either we need to argue that there can be two fundamental locative relations, recasting the definitions as brute necessities; or we need to argue why one is fundamental and the other isn't, which seems difficult at first glance.

In this section I'd like to explore a line of argument that suggests weak location is a better candidate fundamental location, precisely because of the way that Perfectness holds only in certain well-behaved spacetimes. Since mereological overlap on regions is well-defined in every spacetime (even if it holds only trivially between regions and themselves), necessarily every perfectly located object has a weak location. But Perfectness may not be a necessary truth, and if so, perfect location isn't a fundamental relation, since weak location, rather than it, contributes the locative ingredient to a those possibilities in which Perfectness has counterexamples. Moreover, even if there were not counterexamples to Perfectness, weak location is only definable from perfect location with the help of a subsidiary principles about the mereology of spacetime. This dependence on other principles which aren't about location at all already may indicate – though it is far from conclusive – that perfect location isn't fundamental to location.

[10] Parsons (2007: 205) calls this 'Exactness', given his terminological choices.

5.1 Gunky and Junky Spacetimes

Two kinds of counterexample to Perfectness might be considered. One has already received attention in the literature (Parsons, 2007: 209, Uzquiano, 2011: 214–5 and Gilmore, 2018: §2): the case of *gunky* spacetime. In these cases, spacetime lacks mereologically atomic regions ('spacetime points') while the pattern of instantiation of weak location of some object x is such that if x had a perfect location, it would have to be at a point. Our mereological assumptions are consistent with atomlessness. An example which may help to fix ideas is Tarski's model of gunky space, 'a system of geometry destitute of such geometrical figures as points, lines, surfaces, and admitting as figures only solids' (Tarski, 1929: 24). Setting aside the metrical and topological aspects of Tarski's construction, which complicate matters somewhat (Russell, 2008), the spacetime admits only of regions which are mereologically complex.

Call an object *small* if it is weakly located somewhere, but fills no region (and hence lacks a perfect location). By R-delegation (3), if the small object is weakly located somewhere, it will be weakly located in some proper subregion too. The typical small object is in fact confined to each region in an infinite sequence of nested mereologically complex regions – which would converge in the limit to a mereologically atomic spacetime point, if there were any points. (They converge to what would be their intersection, but no region in such a spacetime is their intersection.) An object with this pattern of location is confined to a subregion of any region R at which it is weakly located, hence does not fill R. While small objects 'are intuitively "point-sized", there are no point-sized regions to serve as their perfect locations' (Uzquiano, 2011: 215). Suppose we specify a converging sequence of regions S, and then describe a pattern of weak location as follows: let x be weakly located in all and only regions which overlap some region occurring in S. Since the regions in S are not disjoint, it does not directly follow from our Redistribution principle that this pattern is possible. Yet the basic idea of recombination suggests that it should be possible to instantiate weak location in just this pattern, if this kind of spacetime is possible, and those who have thought about gunky spacetime have typically taken such objects to be possible on broadly combinatorial grounds – e.g., Leonard (2018: §3) discusses temporally small persisting objects that he calls 'thin endurers'. If we agree that small objects are possible, then, as many have noted, we have a counterexample to Perfectness.

The other sort of potential counterexample to Perfectness involves spacetimes which may bottom out in spacetime points, but which are *unbounded* at the top. That is: for every region, there is a *superregion*: a distinct region containing it ($\forall R \exists S (r \sqsubseteq S \wedge r \neq S)$). Such a space is called *knuggy* (Parsons, 2007: 209) or *junky* (Schaffer, 2010: 64–5); the latter term has gained the upper hand in the literature. In a junky space, while there is no upper bound on the size of finite regions, there is no region of infinite size, so no maximal region.

If junky space is possible, then Redistribution entails that there are objects which are too big, mereologically speaking, to fit into any region. For there is a distribution which assigns x to every point, and by Redistribution, x is weakly located at every point, and hence by R-Inheritance, x is in every region. (Remember: this doesn't mean that x is multiply located at each point; it might be weakly located at each point in a more boring way, by having a distinct simple part confined to each of those points.) If there is a big object in a junky spacetime, it lacks a perfect location, because it cannot be confined to any region (being also in points in the complement of that region). So big objects in junky space also provide counterexamples to Perfectness.

Is junky space possible? I think so, though the case isn't as straightforward as in the case of gunky space. Here's a couple of ways we might construct it.

Non-existence of a Largest Region The simplest is to take the metaphysical necessities about subregionhood to be characterised by Minimal Extensional Mereology. This theory has models in which some collections don't have a fusion (e.g., an ordinary Euclidean space with the 'top' element deleted). So we may consistently with this theory construct a scenario in which, while there is a plurality of all the regions, there is nothing which is the fusion of this plurality. If MEM or any *weaker* theory of mereology turns out to characterise the metaphysical necessities about the subregionhood relation, then there are metaphysical possibilities in which the structure of space is junky and unbounded.

Non-preservation of Regionhood For most predicates F, this preservation schema is false: ⌜ the fusion of some Fs is an F ⌝. We ought not assume without further argument that 'is a region' (or perhaps 'is a receptacle') is one of those predicates for which this schema does hold. If we accordingly think it possible that some fusion of regions is not a region, many possibilities open up. We can keep full Classical Extensional Mereology for parthood and subregionhood, and so accept that any collection of

> regions has something which is its fusion, while denying that the fusion is be a region.[11]
>
> Define a *receptacle* as a region of space (spacetime) which is the possible exact location of a material object – it is a place something could be. We might want to say that anything which counts as a legitimate region of spacetime should be a receptacle, and that receptacles must be 'well-behaved' in some sense – not mere fusions of arbitrary spacetime points. E.g., we might wish to deny that disconnected things could be the place of a material object, and hence deny that there are scattered receptacles. On this kind of moderate view of receptacles (Cartwright, 1987; Uzquiano, 2006), many fusions of points aren't receptacles and hence not regions either. Junky space emerges as a by-product of the moderate idea that all receptacles should be *finite*. This claim would be novel, but not entirely unprecedented. For example, Pashby (2016: 280–1) requires that a receptacle for a quantum system must be bounded. If every receptacle is finite, and every region is a receptacle, there are no infinite regions. Yet the finite regions need not have any mereological upper bound. So this may well give us a structure in which every finite region has a finite proper superregion, without there being any maximal region, since the fusion of all points is too big to be a region.[12]

Probably the approach to junky spacetime via a weaker mereology that denies the existence of some fusions is more plausible than the view which accepts those fusions exist but denies they are regions. (The preservation schema seems fairly plausible for such generic sortals as 'is a thing' or 'is material', so maybe it holds for 'is a receptacle'.) I don't mind one way or another; I do think it is as plausible that there can be junky spacetimes in topless mereologies as that there can be gunky spacetimes in bottomless mereologies. Either way, couple the possibility of junky spacetime with our previous discussion and we conclude that there are possible counterexamples to Perfectness.

[11] Contra Parsons (2007: fn. 5), who claims that CEM is flatly inconsistent with junky space.

[12] This way of arguing for junky space is related to an argument offered by Oppy that proponents of gunky space should reject the thesis that 'regions have no parts other than regions, and are parts of nothing other than regions' (Oppy, 1997: 249). According to the present approach to junky space, some regions are parts of things that are not regions, even though those things fuse some regions.

5.2 Mereological Harmony

In the above scenarios, the mereological structure of spacetime and the mereological structure of its inhabitants diverge – the small object is mereologically simple, but there are no mereological simple regions of spacetime for it to inhabit; the big object is the fusion of a bunch of perfectly located parts, but there is no region fusing those locations. (Parsons, 2007: 209) notes that these kinds of scenarios 'complicate the relationship between the geometrical properties of material things and the geometrical properties of space'. In the cases described above, no topological or metrical features are mentioned, so the complication involved in those cases must lie in the relationship between the mereological features of space and the mereological features of its material occupants.

Accordingly, these cases provide counterexamples to this principle:

Harmony Necessarily, 'mereological relations on material objects each mirror and are mirrored by mereological relations on their [perfect] locations' (Uzquiano, 2011: 204).[13]

Uzquiano shows that the intuitions behind Harmony can be formulated in a way that avoids the presupposition of Perfectness, as a battery of weaker principles about parthood, overlap, and fusion (Uzquiano, 2011: 211). (For example, one of these principles ($1@_\circ$) is that x is part of y iff y is weakly located in every region in which x is weakly located.) When combined with Perfectness, Uzquiano shows that these weaker principles entail Harmony; but that without Perfectness, they do not. The possibility of a big object in junky space is consistent with all of these weaker principles, as is the possibility of a small object in gunky space. (For example: since every part of the big object is in some region, and the big object is in every region, ($1@_\circ$) is satisfied.)

Further possibilities violating Harmony follow from the fundamentality of weak location plus Redistribution. Recall examples involving weak coincidence in section 4. In a case of perfect coincidence, as in a crowded simple, distinct x and y can be perfectly located at the same region. This violates Harmony, since the perfect location of x is an improper part of the perfect location of y without x being an improper part of y.

The dedicated lover of Harmony might take these cases to be a reason to reject fundamental weak location. But in the dualist framework we have adopted, the two relata of locative relations are fundamental and distinct kinds

[13]See also Gilmore (2018: §3).

of things, regions and material objects, each with their own intrinsic mereological structure (McDaniel, 2007: 137). It would be puzzling for the dualist to insist that, nevertheless, the first kind of thing *of necessity* shares a mereological structure with the second kind of thing when they stand in the locative relation of perfect location. Relationalists who reduce spacetime to objects and their relations, and supersubstantivalists who reduce material objects to spacetime, both have metaphysical explanations for the necessary alignment captured in a principle like Harmony. But for the dualist, arguably the truth of Harmony would have to be brutely necessary (Dorr, 2008: 53). And it is widely accepted that such brute necessities are objectionable (Skow, 2007: 116).

There is much more to be said here.[14] Maybe some reductionist story about material parthood can be told that salvages Harmony without positing brute necessities. But *prima facie* orthodox substantivalists ought to reject Harmony, and the resulting story they tell about the relationship between the mereological structures of objects and their locations will permit multiple kinds of misalignments. These cases may be counter-intuitive. But I see no prospect that orthodox substantivalists can in good conscience avoid their possibility. If one is committed to the thesis that all objects in space must have well-behaved perfect locations and exhibit a pleasing alignment between their mereological and geometrical structure and that of their perfect location, then one would be well-advised to opt for supersubstantivalism instead.

5.3 Kleinschmidt On Perfectness

Kleinschmit (2016) has recently offered another kind of non-standard spatial structure which provides counterexamples to Perfectness. In her theory, space is governed by CEM and there are spatial atoms – so far, so orthodox. But her spatial atoms have non-zero volume – they are *metrically extended*. Presumably Kleinschmidt has some non-mereological view of extension to offer – a primitive mapping from regions to numbers, which determines an *atomic* measure on regions. (That is one where a region has positive measure even though it has no subregions of positive measure.) Her case 'Almond in the Void' is illustrative:[15]

> There is an extended, simple region, r, and an almond (and its

[14] I say much of it elsewhere: Eagle 2016b.

[15] Similar cases have been raised with me independently in conversation by Kristie Miller and Dan Marshall.

> parts) which is smaller than r and seems to be entirely located in r. Region r is otherwise empty, and there are no other regions. (Kleinschmit, 2016: 122)

Of course, the almond α is weakly located in r, and since r is simple, $\alpha \mathrel{@_{\geqslant}} r$, by definition. Since α is confined to r, the perfect location of α is r. This bears out Uzquiano's point – the existence of atoms and the endorsement of CEM show this is no counterexample to Perfectness.

But, Kleinschmidt says, the almond α doesn't intuitively fill r, because the almond has a *volume* smaller than the volume of r.[16] In this sense, there is a mismatch between the smallest spatial regions and the size of material objects. But it is not a mereological mismatch (simples are perfectly located at simples) – it is essentially metrical. Nothing in the mereo-locative framework with weak location as fundamental says anything about geometry. Kleinschmidt thus needs a further principle, such as *if the volume of x is smaller than the volume of R, then x doesn't fill R*, to get her case up and running. There are two attitudes we might take to such a principle.

The principle is derivatively true Following what we've just said about grounding the alignment of properties between material objects and regions, we might explain the volume of a material object as *inherited* from the volume of its perfect location. If so, the principle can be proved, given weak supplementation for regions. But then 'Almond in the Void' is impossible: the perfect location of the almond is r, so they necessarily share a volume, and the almond does fill r.[17]

The principle is false On the other hand, if the volume of a material object is specifiable separately from its perfect location, then (again to avoid brute necessities), we should admit the possibility of misalignment between perfect locations and volumes. In the case in question, the almond does fill r in the sense defined here – none of r is free of it – and

[16] Kleinschmidt offers a rather misleading diagram, which models a simple region r with positive measure by a mereologically composite region of Euclidean space with the same measure. A better diagram would have the almond and the region perfectly coincident at a simple region, and two different numbers attached to them.

[17] Kleinschmit (2016: 131–3) considers a related inheritance principle, that volume is inherited from exact location; she notes that there needn't be such an exact location as a way of sidestepping the response. But that sidestep is not available for inheritance of volume from perfect location, which is well-defined in her cases.

> has a smaller volume, showing the principle to be false. Of course in normal cases the principle holds, because generally when x has a smaller volume than r it is because x is perfectly located at a proper subregion of r, whence again it follows that x doesn't fill r. But we shouldn't expect these sorts of principles to continue to hold once primitive volume, which is entirely separate from mereological structure, is in the picture. Indeed, why can we not construct counterexamples to the principle by recombination of weak location – if x is actually perfectly located at a region with the same volume as x, then Recombination allows us to construct a possibility in which it is perfectly located at a region with a different volume.

Much as I am sympathetic to failures of Perfectness, I am not persuaded the defender of fundamental weak location has to accept the possibility of her cases, so cannot use those cases to illustrate such failures. For the record, Kleinschmidt too is sympathetic to the idea that we ought to reject the possibility of extended simple spatial regions. I don't object myself to the possibility of atomic volume measures, which assign positive measure to spatial points. I just want to resist the idea that they have anything much to do with the mereo-locative notion of a material object's filling a region.

6 Extended Simples

An *extended simple* is an object that is mereologically simple – it has no proper parts distinct from itself – but which (somehow) 'takes up' an extended region. I am not broaching metrical issues here, so I will be understanding extendedness mereologically: a region is mereologically extended iff it has a proper subregion.[18]

One area in which extended simples are of metaphysical significance is in the debate over persistence. Those who think objects persist by having temporal parts (mereological perdurantists) are committed to the temporal compositeness of persisting entities. Mereological endurantists, who deny the ex-

[18] This is a liberal conception, since some measure zero regions – such as lines and planes in Euclidean 3-space – clearly have proper subregions and thus turn out to be extended despite having no volume. But (i) it may in fact be a welcome result that lines and planes are extended despite having no volume; and (ii) having positive measure suffices, in an ordinary space, for also being mereologically extended – so that being mereologically extended is a necessary condition for being metrically extended.

istence of temporal proper parts of a persisting object, are therefore committed to the temporal simplicity of any persisting object. But it is not true that enduring objects are temporally unextended in the intuitive sense introduced above, since they obviously aren't instantaneous objects, restricted to a single moment, but instead typically take up an interval of time from their creation to their destruction. If this is right, enduring objects are candidates for being temporally extended simples. I will return to the application of extended simples to endurance in section 7, and clarify the sense in which they are temporally extended. But first let us turn to the question of how to think about extended simples if weak location is the fundamental relation.

In Eagle 2016a, I drew a distinction between two ways that an object could be extended in spacetime, and argue that both are plausible precisifications of *being extended*. For present purposes, what matters is that these definitions are coherent ways of thinking about how objects might occupy extended regions of spacetime, using resources available in the present framework.

Definition 3 (L-extension). x is *l-extended* $\equiv_{\mathrm{df}}$ x is not contained in an unextended region.

Definition 4 (F-extension). x is *f-extended* $\equiv_{\mathrm{df}}$ x is not confined to an unextended region.

Flowing from these two definitions of extension, there will be two concepts of extended simple: *f-extended simples*, which have no proper parts and are f-extended, and *l-extended simples*, which have no proper parts and are l-extended.

Suppose an object x is f-extended, not confined to an unextended region. If x is in some unextended region R, it must therefore be in at least one disjoint unextended region S also. Consider the fusion $R + S$; this region exists, and is extended, since it has a proper subregion. Since x is in S and R, it is in all superregions of S and R, and is therefore in every region that overlaps $R + S$. But it then fills $R + S$. Hence the name: an f-extended object *fills* an extended region (at least in this mereological sense of extended). An object which fills such a region has a good claim to being an extended object, because it cannot be confined to any smaller region.

By Redistribution, it is possible that a simple object o be weakly located in two disjoint simple regions, R and S. As we just saw, o will fill their fusion $R+S$. So it is a possible simple object which fills an extended region; therefore, f-extended simples are possible.[19]

In fact, this simple will be wholly located in each of R, S, and $R + S$, from the definitions. (It fills each of them, and since it is itself simple, it has no parts that are not in those regions, so is contained in each.) So it is wholly located in multiple regions. This yields another characterisation of an f-extended simple: it corresponds to McDaniel's notion of a *multi-locater*: 'it is extended in virtue of covering an extended region' (McDaniel, 2007: 134). In our framework, the f-extended simple is wholly located at multiple disjoint regions, which is one legitimate way of using the term 'multi-location'.[20]

But an f-extended simple need not be l-extended. An object might fill an extended region while being capable of being contained in an unextended region. In the case above, the simple object o is contained in R and S (as it is in each of them, and has no parts that are not in each), and so is contained in two simple regions. In general, since an object can fail to be confined to a region in which it is contained, there is the prospect that an f-extended simple will not be l-extended. The converse is not true: if an object is not contained in an unextended region, it is not confined to such a region. So any l-extended object would also be f-extended.

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[19] This argument from Redistribution can be usefully compared with the following adaptation of an argument from Sider:

> The possibility of [f-]extended simples follows from plausible principles about location and possibility; mereology has nothing to do with it. The principle about location is that [weak] location is a fundamental relation between objects and [regions] of space. The principle about possibility is a combinatorial principle requiring, roughly, that any pattern of instantiation of a fundamental relation be possible. These principles imply the possibility of the [weak] location relation's holding in a one-many pattern between a mereologically simple object and [regions] of space – an [f-]extended simple. (cf. Sider, 2007: 52.)

As the citation suggests, the quoted text adapts an argument due to Sider. But – as the essential use of the inserted material in square brackets shows – this is *not* Sider's argument. He too follows a combinatorial route to extended simples. But he does not disambiguate the different senses of 'extended', and he treats exact location as the fundamental relation. I am happy to endorse the general strategy, but in detail Sider's argument and my own are quite different.

[20] This conception of f-extended simples – multiply wholly located at many unextended regions, but managing thereby to fill an extended region – appears elsewhere in the literature, though under different names. For example, Parsons (2000: 404–6) defends this kind of account of enduring simples, when he discusses objects that *entend*, 'filling space by being wholly located in each of several places'. Similar formulations can be found in Zimmerman 2002: 402 and Sider 2007: 52.

McDaniel discusses some entities, which he calls 'spanners', that would be l-extended simples, if they existed:

> According to this conception, an extended simple bears the occupation relation to exactly one extended spatiotemporal region, without bearing the location relation to any proper part of that extended region. Spanners are not multi-located; they uniquely occupy a single extended region of space-time. (McDaniel, 2007: 134)

Why would spanners be l-extended simples? McDaniel's definition is phrased in terms of exact location; we can approximate it using our notion of whole location. The adapted definition says that if x is a spanner wholly located at R, it is wholly located at no subregion of R. The spanner thus is contained in R, but in no subregion of R. So it is not contained in any unextended region within R. It would thus be an l-extended simple.

Unfortunately, there is a straightforward argument in the present framework that no l-extended object can be simple, at least in standard space.

Proof. Assume for *reductio* that there could be an l-extended simple; then there is a simple object x which is contained in an extended region but is contained in no simple region. Since x is not contained in a simple region, it must fill an extended region – call that region R. Take some simple part r^* of R (assuming standard space). Certainly, x fills r^*, because it fills a region of which r^* is part. But r^* also contains x.

To see this, assume that r^* does not contain x. Then some part of x is not in r^*. But since x has only one part, itself, that would mean that x is not in r^*. Which would mean that x is not in some part of R, and hence that it does not fill R, contrary to assumption. So r^* must contain x.

So x is contained in (and fills) a simple region r^*, and this is not an l-extended simple – it is at best an f-extended simple. □

The argument can be resisted. Perhaps we've done spanners an injustice by trying to capture them using whole location. McDaniel's definition of spanners involves a locative relation that can be borne by a simple object to a region without bearing it to any subregions. Perhaps we might charitably reconstruct his argument by translating his 'occupation' by our *perfect location*, which has this feature (while whole location does not). If we make this interpretative assumption, a spanner would be an object that is perfectly located at an extended region. But if the object is simple, and perfectly located at an extended region, it will also be contained in and fill all the simple parts of that location. On this interpretation, unlike the last one, spanners are perfectly possible – they are just f-extended simples!

In fact, in terms of the distribution of weak location, and of filling, containment, and confinement, spanners and multi-locators amount to *precisely the same thing*. The pattern of weak location induced by an spanner which exactly occupies R, and the pattern of weak location induced by a multi-locator which occupies regions which R fuses, are precisely the same pattern. So taking weak location to be the fundamental relation, there is no way of drawing a meaningful distinction between these two kind of extended simples.Once we specify the distribution of the weak location, any extended simples that arise are f-extended simples. The only way to get a difference between spanners and multi-locators is to think that there is a genuine metaphysical issue in how 'occupation' gets glossed. But as we are assuming that relation not to be fundamental, there is no difference in fundamental facts that corresponds to the putative difference between spanners and multi-locators. Spanners are just multi-locators alternately described, as things which have an extended perfect location versus things which fill an extended region. But this difference in description corresponds to exactly the same underlying distribution of the fundamental property, weak location.

This result is a useful one. Some will say: so much the worse for the obscure metaphysics of 'occupation', giving rise to a distinction without a difference between spanners and multi-locators. Others might say: if a framework taking weak location as basic can't capture the difference between these two quite different ways of being an extended simple, so much the worse for the framework. It is not my aim to adjudicate this dispute here. But the example does crystallize attitudes. The friends of weak location are apt to see this result as a benefit, since it shows how taking weak location as fundamental clears up a spurious bit of metaphysics. The orthodox position is probably that it is a cost, because weak location is too weak to have the expressive power to capture a genuine locative difference.

6.1 A classic argument revisited

Some have claimed to have identified tensions between extended simples and other attractive principles. Most notably, there is an argument (which goes back to Descartes, in *Meditation* VI – see also Hawthorne 2008: 270) which is sometimes given against extended simples, along the following lines (Markosian, 1998):

(3) An extended simple has two halves ;

(4) If something has two halves, it has two distinct parts ;

(5) Therefore: an extended simple has two distinct parts.

Since (5) is self-contradictory, something has gone wrong. The argument is obviously valid. Let's grant (3), for the sake of argument (letting 'halves' mean 'halves of its location'). So the culprit must be (4).

Something like (4) would follow from the principle of *Arbitrary Partition*:

AP For any material object x which is weakly located in space, if x fills a region R, then there is a material object x' which is part of x and which is located at R.

While AP looks plausible, it does involve the use of the exact location relation, and so is not expressed in the most fundamental language. There are two natural relations which were defined in terms of our fundamental locative relation on page 5: wholly located at and perfectly located at. If we clarify AP, by substituting the precise relation *is perfectly located at* for *located at*, then f-extended simples provide counterexamples to AP. An f-extended simple can be confined to a region without being confined to a part of that region, as we've seen, so AP is false under that substitution.

What if we precisify AP by taking *located at* to indicate *is wholly located at*? Then we arrive as this precisification of AP:

AP* For any material object x which is weakly located in space, if x fills a region R, then there is a material object x' which is part of x and which is wholly located at R.

This principle appears to closely resemble AP. In cases without multiple location or extended simples, AP and AP* are equivalent. It has been thought that AP* also yields something like (4) in the argument above. But it does not. AP* at most entails that, for an object which fills an extended region, there are parts of the object that fill and are contained in parts of the region. In the case of an f-extended simple, it entails only the triviality that the extended simple fills up and is contained in that part, without being located there. So (4) does not follow from AP*, and one could consistently maintain the existence of f-extended simples alongside a commitment to AP*.

7 Endurance

As flagged earlier, one of the main metaphysical applications of extended simples is in the theory of persistence. Lewis characterises the endurantist view he rejects in locative terms: 'a persisting thing is multiply located in time: the whole of it is at one time and also at another' (2002: 2), and many have followed this lead. How do things look when we represent the debate over persistence using weak location?

Gilmore offers a useful characterisation of persistence using locative notions:

> a region *R* is an object's *path* ... just in case *R* has a subregion in common with all and only those regions at which the object is weakly located. This captures the thought that a thing's path is the region that exactly corresponds to the thing's complete history or career. ... we can say that a thing *persists* just in case it has a path that is not achronal [temporally unextended]. (Gilmore, 2008: 1228)

As it makes use only of weak location, this definition of a path is acceptable to us.

The standard characterisation of endurance as a theory of persistence maintains that objects persist by being *wholly present* within each time (more generally, each achronal region of spacetime) at which they exist. 'Wholly present' connotes two further ideas, both of which have been commonly associated with endurance in the literature:

1. The object is not merely partly present at each time; it therefore lacks *temporal parts*, parts which it has but which exist only for some proper part of the object's existence;

2. The object is 'all there' within any time at which it exists, so can be wholly contained within each time.

Associated with the first idea is a mereological conception of endurance as opposed to temporal parts; associated with the second is a locative conception of endurance as opposed to the object being containable only in temporally extended regions.

There is a natural conception of endurance that respects both of these connotations of 'wholly present'. This is the view that enduring things are temporally extended temporal simples. That is, they may be divisible into parts along spatial dimensions, but not along the temporal dimension. All their simplest parts are extended simples *simplicter* because each of them fills its temporally extended path. So enduring objects are are f-extended temporal simples, multiply wholly located at (among other places) every achronal subregion of their path.[21]

The possibility of such enduring objects follows by Redistribution in the same sort of way that the possibility of spatially extended simples does. Redistribution entails the possibility of a distribution of weak location under which we populate an entire spatiotemporal region P by partitioning it into many many temporally parallel paths each of which is simple at each time, and associate each disjoint path with a unique object which is weakly located at it and at it alone among regions in this partition. If the simples chosen have the right intrinsic character, and alter over time in appropriate respects, there will be a thing which fuses them, and which is the unique material thing perfectly located at P. That thing will persist in Gilmore's sense, with path P, and will be an enduring object in our sense. Accordingly, there is no prospect, given locational dualism, that endurance is impossible and that perdurance is, necessarily, the only viable account of persistence.

It may even be that this gives us an argument for the actuality of endurance. As Sider says, 'if there are wholly present entities, the best candidate for change [over time] might involve them' (Sider, 2001: 216). Since there are, in other possibilities at least, things which persist by being wholly present, those things are the best candidate deservers of the name *persisting entity*. Of course the locative framework here allows for entities which occupy a temporally extended region P in virtue of having distinct parts perfectly located at each point in P – these would be entirely orthodox perduring things. But as Sider notes, these are arguably not persisting things – they involve successive replacement over time of one part by another. If they were all we had, they would be the only candidate for persisting things and near enough is perhaps then good enough. But in the present framework, we can do better. So if we are convinced that anything persists actually, then those things persist by enduring. Of course if we were in a world of mereo-locative perdurance, we might then conclude that whole nothing 'really' persists, the surrogate notion does all the work we need. So of course this argument just pushes the pieces

[21] In the relativistic context, I am here endorsing what Gilmore (2006: §4.1) calls (in the course of objecting to it) the 'every slice' principle. Gibson and Pooley (2006: §5) offer some considerations in its favour. The principle has also been criticised by Balashov (2010: §5.5); I reply, again in favour of the every slice principle, in Eagle 2011.

around the board without removing any.[22]

7.1 Is there another way to endure?

Neat as it is, this perspective is not universally shared in the literature on endurance. Some have argued that the notion of multiple location is incoherent, undermining locative characterisations of endurance (Barker and Dowe, 2004; Calosi, 2014; Kleinschmidt, 2011). The framework of the present paper rebuts these arguments by offering a framework in which a species of multiple location is unproblematic.[23]

Here I wish to address instead another issue: whether this is an adequate characterisation of the debate over persistence. Both Cody Gilmore (2008: 1227–30; 2018: §6.3.2) and Maureen Donnelly (2011) offer another view they regard as a kind of endurantism, because it says that persisting objects are temporally extended temporal simples. The same view is discussed, though not given the honorific 'endurantist', by Miller (2009) ('terdurantism') and Daniels (2014) ('transdurantism'). The view accepts that there are no temporal parts, so is mereologically endurantist. But it rejects the orthodox endurantist idea that a persisting object is wholly present at any temporally unextended region. Rather, the object is wholly present just once, at its path. In this, it resembles perdurantism. If, with Donnelly (2011: 49), we characterise the endurance/perdurance debate as one over the *dimension* of the location of persisting objects, this turns out to be a variety of endurance. If we focus instead on the denial that objects which persist in this way are wholly present at each moment at which they exist, then we will not wish to classify it as endurantist.

Whether it is endurantist or not, the view would be an interesting further option, the benefits of which deserve evaluation alongside more familiar options in the persistence debate – if it is coherent. If we help ourselves – as those cited above generally do – to fundamental exact location, the view can be simply expressed: persisting objects are temporally l-extended simples,

[22]If we reject the dualist framework, and accept something like supersubstantivalism, things are very different. As I've argued elsewhere, perdurance is very natural in such a framework, and endurance faces difficulties (Eagle, 2016b).

[23]I offer a more extended response to those arguments elsewhere (Eagle, 2016a). I do not there directly engage with Calosi 2014, but it is easy to see what to say in the present framework: that Calosi chooses the wrong primitive, and that all of his locative principles (Calosi, 2014: 125) have counterexamples that may be easily constructed using the resources above.

spanning and being exactly located at just one region, their path.

Accordingly, the view is distinctively new only if we are able to make sense of the distinction between f-extended and l-extended simples. We would be able to make this distinction if exact location is fundamental. But in our framework, where weak location is fundamental, I've argued that putative l-extended simplehood collapses to f-extended simplehood (section 6). We cannot in fact make the requisite distinctions. So this purportedly alternative view is not alternative after all; it is endurantism.[24] Once again, this is grounds to deny that weak location is fundamental – that if several good philosophers can entertain and evaluate a view, we had better not adopt a fundamental framework which collapses that view into an existing more familiar one. On the other hand, not all conceptual distinctions correspond to genuine distinctions among things.

In the framework with weak location as fundamental, there is only one way to endure: to have no temporal parts, and to fill a temporally extended path. And, likewise, there is only one way to perdure: to have temporal parts. Some perduring objects, for all we've said, could have multiply located parts. This means that while they are perfectly located at their path, they are wholly located at many distinct regions (some quite exotic and scattered.) But the key to the debate between endurance and perdurance remains a disagreement over temporal parts.

Donnelly's claim that 'the core of the endurantist and perdurantist debate over persistence might be construed as a dispute over how objects are located in spacetime' (2011: 49) holds only if exact location is the fundamental relation; and we are assuming it is not. To follow her characterisation there would have to be one unique best candidate to be *the* dimension of a material object. But an enduring thing is perfectly locatable only at a 4D region; and wholly locatable at a 3D region. Should we say it is 'really' 3D? 'Really' 4D? Why should we choose? The pattern of weak location determines the nature of those regions filled by the enduring thing and in which it is contained and confined. To say anything further would be to try and engage in the rather idle game of trying to re-collapse the distinctions we have drawn so as to make some questions of pre-theoretical English determinate – questions such as 'What is Descartes' temporal extent?' But as van Inwagen said about this very ques-

[24]Gilmore (2018: §6.3.2) claims that Parsons accepts mereological endurance while rejecting multi-location. This is false. For Parsons, enduring objects, like all objects, have one perfect location. But he does not think this means multi-location, in the sense of multi-whole-location, is impossible. In fact his *definition* of endurance involves an object being 'wholly located at every time at which it exists' (Parsons, 2007: 218).

tion, the endurantist

> believes that Descartes occupied R_1, which is of zero temporal extent, and also occupied R which has a temporal extent of fifty-four years-and, presumably, that he occupies regions having extents whose measures in years correspond to every real number between 0 and 54. Therefore, in his view, Descartes did not have a unique temporal extent. (van Inwagen, 1990: 252)

Rather, a framework with weak location makes possible many disambiguations of 'temporal extent' (temporal extent of minimal whole location? temporal extent of perfect location). Once disambiguated, the ordinary question corresponds to many precise questions, each with an answer straightforwardly determined by the underlying pattern of instantiation of weak location.

7.2 Endurance and mereological change

One issue we need to confront is the nature of change, especially mereological change, for enduring objects. Our framework uses a standard two-place parthood relation between things, and it is obvious that in such a framework endurance faces challenges when objects change their parts over time, because they cannot appeal to either temporal parts or some covert parameter to defuse the apparent contradictions that arise when an object changes, first lacking some part and then gaining it. This may motivate some to seek to reformulate the work of the present paper in a mereology where parthood is 3- or even 4-place (Gilmore, 2009; Kleinschmidt, 2011). They are most welcome to do so.

I myself prefer to explore the consequences of 2-place parthood. One reason is that many of the definitions from F-extension 1 break down once we move to a 3-place parthood relation. Consider containment: x is contained in R iff all of its parts are weakly located in regions overlapping R. If we add a slot for a time argument, then trivially any object is contained in any time within which it exists since all of its parts at that time will trivially be within that time. More fundamentally, I find it implausible that the idea of part possession relative to a time (or a region) is genuinely primitive, somehow more basic than the simpler mereological and locational relations of having parts and being located somewhen and somewhere.

Perhaps the neatest approach for endurantists who favour orthodox mereology is to restrict persistence by enduring to permanently simple entities, such as (maybe) the fundamental particles, which lack proper parts. The story this sort of endurantist would go on to tell about complex objects may resemble a sort of nihilism about material things, treating changing complex objects as constructed from a sequence of variably constituted aggregates of enduring simples. Or it may involve something like Fine's notion of 'variable embodiment' (1999). In either case, the complex objects will be more like ideal entities than simple material things, which do persist by enduring. In any case, I wish to set aside how the endurantist should treat mereological inconstancy. The above discussion already shows that endurance is viable, since it is offers a consistent theory of how simple things, at least, persist, and a theory that (because it is formulated using weak location) cannot be accused of obscurity or unclarity.

8 Weak Location and Exact Location

In this section I wish to briefly undertake a final piece of accounting, which is begin to compare the results of beginning with weak location to what happens when one takes exact location, the more orthodox locative primitive, as fundamental.

Exact location (or exact occupation) is supposed to be that relation which holds

> between a thing and a region just in case … the thing *exactly fits into* the region, where this is meant to guarantee that the thing and the region have precisely the same shape, size, and position. (Gilmore, 2006: 200; see also Balashov, 2010: 18)

Note the requirement that objects and their exact locations must share their geometry: 'a spherical object lying 10 feet from a cubical object exactly occupies a spherical region which is 10 feet from the cubical object's cubical region' (Donnelly, 2011: 30). The distinction between spanners and multilocators we encountered in section 6 depends on this geometrical factor, since those who grasp the distinction will note that spanners have the shape of the extended region they fill, while multilocators do not.

We cannot define exact location in terms of weak location. In the example of extended simples, we saw that the same pattern of weak location (the same regions filled, the same pattern of containment) was compatible with what proponents of exact location see as two different patterns of instantiation of exact location. A spanner exactly located once at a spherical region S of Euclidean spacetime will be perfectly located at a spherical region and wholly located at every point within it; a multilocator which is exactly located at each and every point in S has the same whole locations and the same perfect location. So exact location doesn't even supervene on weak location, let alone be definable in terms of it.

If we assume that every object has an exact location, the principle called Exactness in the literature, then we can however define weak location in terms of exact location:

Definition 5 (Weak location from location). x is weakly located at R iff some exact location of x overlaps R. In symbols:

$$x \mathbin{@_\circ} R \equiv_{\mathrm{df}} \exists S(x \mathbin{@} S \wedge R \circ S).$$

This definition, given the plausible supplementary principle that if x is exactly located at R, then x's parts are exactly located at a subregion of R (Parsons, 2007: 213–4, Sider, 2007: 75), entails that necessarily, if x is exactly located at R, then it is wholly located at R. (As we just saw, the converse does not hold.)

Perhaps the most natural response to this result is to say, *so much the worse for weak location*. If we cannot define location in terms of weak location, but it is possible to define weak locations in terms of location (definition 5), that suggests that exact location is the better candidate fundamental relation.

But this definition – like the attempted definition of weak location from perfect location in section 5 – is hostage to whether spacetime has the right structure to ensure that every object has an exact location. The cases of big and small objects will also provide counterexamples to Exactness, because those objects lack whole locations (the small object being too small to fill any region and the big object too large to be contained in any region, at least if it is in every region in the normal way by having different parts at different places). But, because of the geometrical restrictions on exact locations, there will be still further potential counterexamples to Exactness, even in spaces with entirely standard geometries. The case of quantum indeterminacy of position may provide an example. An object may have no exact location because it cannot be localised to any region with the appropriate shape and size, and yet have well-defined weak locations, because it is weakly located at any place where it might be found on measurement (and at any regions overlapping such places). If this scenario shows the falsity of Exactness, facts about weak location will not supervene on facts about exact location. For there will be possibilities that agree in all the facts about exact location but disagree on weak location – e.g., they agree that x has no exact location, but disagree on where x is weakly located. Even if Exactness is true, the discussion of potential counterexamples to it shows that it is not analytic, and hence that weak location and exact location are not analytically connected as the purported definition 5 would have it.

Where does this leave us? We have a proposed definition of weak location from exact location that is hostage to the fortunes of Exactness. On the other hand, we have some putative cases where a distribution of weak location fails to fix the distribution of exact locations. Taking them both as fundamental is unappealing, since in most cases fixing one relation is enough to fix the other, and we'd have to explain why (if each is fundamental) there are a bunch of brute necessities connecting them. So it will come down to whether we wish to accept Exactness, or can somehow explain away the putative cases showing that exact location doesn't supervene on weak location.

The latter course may be prosecuted as follows. In those cases, we know which regions the object is in, and thus which regions it fills and is contained in. We know that it is wholly located in some point sized regions, and some extended regions. We know precisely where it is to be encountered, and which regions are completely or partially free of it. The residual issue about exact location seems to be a merely verbal one: which of the whole locations of the object should we like to call *locations* in the ordinary sense – which of these whole locations best tracks the *concept* of location that we happen to start with? However we decide to resolve that conceptual question, there would be one and the same underlying possibility described here: the possibility whose locative facts are fixed completely by the distribution of weak location. There are lots of precisely defined properties which are candidates to capture part of what we might be trying to mean by ordinary uses of *location*. We can very closely approximate the behaviour of the ordinary word *location* in the usual sorts of cases by using relations that can be precisely defined in the present framework. Even if this hope isn't fully realised because the ordinary concept is too unruly, we can still say much concerning locative matters of ordinary interest, without risk of error through imprecision, in the present framework.

This line of argument can be resisted, and I don't expect that this brief treatment will convince location-fundamentalists to switch sides. But the problems with Exactness, and the simplicity of the relation of weak location, mean that taking weak location as fundamental remains a promising idea.

9 Conclusion

The present paper is an exercise in fundamental metaphysics, not conceptual analysis. I have no view one way or another about the psychology of our basic locative thoughts and their conceptual underpinnings. It could turn out, even if weak location is fundamental, that spanners are conceptually possible, by the conceptual analogue of a recombination argument. I think things probably will turn out this way; it would be surprising if the excellent philosophers who have defended spanners were making a *conceptual* mistake.[25]

But if weak location is in fact the fundamental locative relation, they are making a mistake. It would be interesting – for debates over mereology, persistence, and coincidence – if weak location were the fundamental relation and subject to Redistribution. Existing questions take on a precise and distinctive and interesting form in a framework which takes weak location to be fundamental, and may be fruitfully addressed. But the approach has costs too, the main one being that perhaps weak location is too weak to enable us to fix all the facts we would intuitively have hoped a fundamental relation would fix.[*]

[25] This is the challenging line that Parsons (2008) needs to prosecute, given that he does intend his contribution to be a logical analysis of the concept of location.

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