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USING MEREOLOGICAL PRINCIPLES TO SUPPORT METAPHYSICS

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Mereological principles are sometimes used to support general claims about the structure and arrangement of objects in the world. I focus initially on one such mereological principle, the weak supplementation principle (WSP). It is not obvious that (WSP) is prescribed by ordinary thinking about parthood. Further, (WSP) is not needed for a fairly strong formal characterization of the part–whole relation. For these reasons, some arguments relying on (WSP) might be countered by simply denying (WSP). I argue more generally that there is no reason to assume that one core mereology functions as a common basis for all plausible metaphysical theories.

I. INTRODUCTION

The weak supplementation principle (WSP) is a mereological principle which many philosophers take to govern the relation between material objects and their parts.[1] (WSP) says: if *x* is any proper part of *y* (i.e., any part of *y* other than *y* itself), then *y* has some other proper part that shares no parts with *x*. Olson, Effingham and Robson, Koslicki and Eagle all use (WSP) in arguments for controversial metaphysical claims.[2] In each of these

[1] As far as I know, the name 'weak supplementation principle' was first introduced by P. Simons, *Parts: a Study in Ontology* (Oxford UP, 1987), p. 28. Simons says (p. 116) that (WSP) is 'analytic – constitutive of the meaning of "proper part"'. Recent work in which (WSP) is posited as an assumption includes G. Uzquiano, 'Receptacles', *Philosophical Perspectives*, 20 (2006), pp. 427–51; J. Parsons, 'Theories of Location', in D. Zimmerman (ed.), *Oxford Studies in Metaphysics*, Vol. III (Oxford UP, 2007), pp. 201–32; A. Varzi, 'The Extensionality of Parthood and Composition', *The Philosophical Quarterly*, 58 (2008), pp. 108–33, and 'Universalism entails Extensionalism', *Analysis*, 69 (2009), pp. 599–604; E.D. Bohn, 'An Argument against the Necessity of Unrestricted Composition', *Analysis*, 69 (2009), pp. 27–31. Like other mereological principles, (WSP) may be taken to apply to all types of entities (properties, events, classes, regions, ...) and not just to material objects. Throughout this paper, I restrict my attention to material objects and their parts.

[2] E. Olson, 'Temporal Parts and Timeless Parthood', *Noûs*, 40 (2006), pp. 738–52; N. Effingham and J. Robson, 'A Mereological Challenge to Endurantism', *Australasian Journal of Philosophy*, 85 (2007), pp. 633–40; K. Koslicki, *The Structure of Objects* (Oxford UP, 2008); A. Eagle, 'Location and Perdurance', in D. Zimmerman (ed.), *Oxford Studies in Metaphysics*, Vol. V (Oxford UP, 2010), pp. 53–94.

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arguments, (WSP) supports a thesis about the kinds of parts objects have, or about how objects are situated in spacetime.[3] This approach to metaphysics may seem like putting the cart before the horse. If we do not already have a pretty good idea of how objects are situated in the world and divided into parts, what reason could we have for endorsing a principle like (WSP)?[4]

In fact, (WSP) is often assumed with little support offered on its behalf. For example, Effingham and Robson merely state without argument (p. 635) that (WSP) is 'eminently plausible and in accord with our intuitions ... [and] is also an axiom of just about every mereology available'.[5] Eagle (p. 76) motivates (WSP) only with the claim that it 'is extremely widely accepted, even by those who reject classical extensional mereology'. When Hud Hudson introduces a variant of (WSP) into an argument for a claim about how objects are divided into parts, he says only that this principle is 'certainly true' without supplying any reason for thinking so.[6] Another sort of problem is that principles like (WSP) are often taken in isolation, without explicit definitions of key mereological terms or an explicit statement of auxiliary principles. We shall see below how such background assumptions may make an important difference in the conclusions warranted by different principles of the same form as (WSP).

In this paper, I initially focus on the use of (WSP) in Koslicki's central argument in *The Structure of Objects*. Koslicki's use of (WSP) is especially

[3] Throughout the bulk of this paper, I do not distinguish (WSP) from the following time-indexed counterpart of (WSP):

> If x is a proper part of y at time t, then y has a proper part at t that does not share any parts with x at t.

Most of the philosophers whose work is discussed below (including both Koslicki and Simons) assume that the parthood relation for material objects is *time-relative*, allowing objects like tables and statues to have different parts at different times. I do not challenge this assumption. However, in the interest of simplicity, I ignore temporal variation where it is not directly relevant to the issues under discussion, and I deal explicitly primarily with principles like (WSP) rather than with the time-indexed counterparts of these principles. (Both Koslicki and Simons also adopt this simplification in much of their work.) It should be obvious how my points carry over to the time-indexed versions of the atemporal principles.

[4] There are, however, important differences in the extent to which various authors rely on principles like (WSP). For example, Olson invokes (WSP) only in a tentative secondary argument for his central claim.

[5] (WSP) is not taken as an axiom (though it is a theorem) in the well known mereologies of A. Tarski, 'Foundations of the Geometry of Solids', in *Logic, Semantics, Metamathematics*, tr. J.H. Woodger (Oxford: Clarendon Press, 1956), pp. 24–9, and H.S. Leonard and N. Goodman, 'The Calculus of Individuals and Its Uses', *Journal of Symbolic Logic*, 5 (1940), pp. 45–55. I am not at all sure what Effingham and Robson count as 'available' mereologies, but there are several mereologies which seem to be both plausible and useful, but which do not include (WSP) as a theorem. I present two such mereologies in §III, and I point out further possibilities in fn. 17 below.

[6] H. Hudson, 'The Liberal View of Receptacles', *Australasian Journal of Philosophy*, 80 (2002), pp. 432–9, at p. 438.

interesting, in part because the principle plays a crucial role in her argument for a key component of her position. Also, she does take the trouble to offer substantial support for (WSP), and to situate (WSP) in a particular mereological theory. But given especially Koslicki's initial assumptions about how objects are divided into parts, the case for (WSP) is far from decisive. I argue in §§II–III that philosophers who like Koslicki hold that objects can have spatially co-extensive proper parts have reason to deny (WSP), and might do so while still endorsing a fairly strong mereology.

A further reason why Koslicki's work is particularly interesting is because the metaphysical theory which she uses (WSP) to support is one that assigns extraordinary parts to ordinary objects. In Koslicki's view, material objects have as parts not only other material objects, but also immaterial components. Olson's arguments are also presented in a context that allows for unusual parts – here, short-lived temporal parts of enduring objects. In Effingham and Robson and Eagle, (WSP) is applied to cases involving an extraordinary way of being situated in spacetime, namely, cases in which objects may travel backwards through time in a way that allows one object to occupy multiple positions at a single time. In §IV, I argue that support for (WSP) and other core mereological principles is especially shaky if we leave open the possibility that objects are divided into parts or situated in the world in exotic ways.

My overall conclusion is that in the absence of general assumptions about what sorts of objects there are and what kinds of parts objects have, we have no reason to endorse principles like (WSP). If this is so, then the best methodology is to develop a mereological theory in conjunction with a particular metaphysical theory, and not to assume principles like (WSP) prior to any more substantial metaphysical commitment.

II. KOSLICKI'S ARGUMENT FOR FORMAL PARTS

Koslicki uses (WSP) to support her claim that material objects, such as, say, a clay statue of Tibbles the cat, have, besides material parts, also immaterial parts. On her view (*The Structure of Objects*, pp. 179–99), the primary immaterial part of the cat statue is a sort of structuring principle for statues – a formal part which determines what kinds of material parts the statue can have and how these material parts must be configured. The details of Koslicki's position on the structuring role of formal parts are not relevant to our immediate concerns. In this section, I focus only on her argument that the statue must have *some kind* of immaterial part. The major steps of the argument are as follows (see pp. 179–81):

1. The lump of clay constituting the statue is not identical with the statue. (Supported by Leibniz's law and the apparent distinction between certain properties of the lump (e.g., its ability to survive squashing) and certain properties of the statue (e.g., its inability to survive squashing).)
2. The lump of clay is part of the statue. (Supported by common sense and the usefulness of this assumption in explaining the shared properties of the lump and the statue.)
3. The lump of clay is a *proper part* of the statue. (From (1), (2), and the definition of proper-parthood: x is a proper part of $y =_{df} x$ is a part of y and $x \neq y$.)
4. The statue must have some proper part which shares no parts with the lump. (From (3) and (WSP).)
5. The extra proper part of the statue invoked in (4) cannot be a material part of the statue – all of the statue's material parts are made of clay (or of small parts of clay) and thus share parts with the lump.
6. Thus the statue must have some immaterial part. (From (4) and (5).)

For the purposes of this paper, the most interesting step above is the application of (WSP) in (4). I will assume (1) and (2). Given our definition of proper-parthood, (1) and (2) tell us that the statue has a proper part which is not smaller than it, but rather is spatially co-extensive with it. The lump constituting the statue is exactly as large as the statue itself. Though this is by no means an uncontroversial position, philosophers besides Koslicki have endorsed the claim that objects may have spatially co-extensive proper parts.[7] If successful, Koslicki's argument would imply that only material objects with immaterial parts have spatially co-extensive proper parts. I will argue that proponents of spatially co-extensive proper parts might reject (WSP) and thus need not admit immaterial parts.

It should be clear enough that (WSP) is indispensable to Koslicki's argument. Without it, even given (1) and (2), we might reject (4) and instead conclude that the statue has a lot of proper parts – the clay legs, ears, tail; the small portions of clay making up these statue parts; the microscopic clay particles; and so on – and that all of these proper parts also happen to be parts of the statue's biggest proper part, the whole lump of clay. Without (WSP), there would be no reason to postulate an additional part that is discrete from (i.e., shares no parts with) the lump.

So what is Koslicki's argument for (WSP)? There are at least two connected arguments for (WSP) in *The Structure of Objects*. The simplest is that

[7] See, e.g., J.J. Thomson, 'Parthood and Identity Across Time', *Journal of Philosophy*, 30 (1983), pp. 201–20, and 'The Statue and the Clay', *Noûs*, 32 (1998), pp. 149–73; Simons, *Parts*; D. Wiggins, 'On Being in the Same Place at the Same Time', *Philosophical Review*, 77 (1968), pp. 90–5.

(WSP) is intuitively (or 'pre-theoretically') plausible. This is what Koslicki states in support of (WSP) when she summarizes her argument for formal parts (at p. 183 n. 24).

A more complicated supporting argument is given in the context of Koslicki's other initial assumptions about the logical properties of parthood. As in Peter Simons' introductory discussion of mereological relations (*Parts*, 1.1), Koslicki assumes that proper-parthood is asymmetric and transitive (p. 168). In other words, she assumes that proper-parthood is a strict partial ordering. But like Simons, Koslicki points out that many strict partial orderings do not embody anything like the kind of structure we might expect in the relation holding between objects and their proper parts. For example, the *strictly less than* relation on the real numbers is a strict partial ordering. But we do not expect all of the statue's proper parts to queue up in linear order as do the real numbers (with each statue part either being part of or having as a part any other statue part). As another example, the relation that holds between any positive integer and its 'proper' divisors (i.e., its factors other than itself) is a strict partial ordering which is not a linear ordering like *strictly less than*. Still, the *proper divisor of* relation has a structure that we might not expect in the proper-parthood relation. All positive integers besides the number one share a common proper divisor – the number one. But most people would not expect all material objects (or even just all parts of the statue) to share a common proper part.

Just specifying that proper-parthood is a strict partial ordering does not get at what distinguishes it from relations that seem to have a significantly different structure. Like Simons, Koslicki assumes that besides the asymmetry and transitivity principles, further principles are needed to differentiate proper-parthood from certain other strict partial orderings. Neither *strictly less than* nor *proper divisor of* satisfies a correlate of (WSP).[8] Thus if we follow Koslicki in granting that (WSP) is intuitively plausible, then (WSP) would seem to be a good way of marking a structural distinction between proper-parthood and these other strict partial orderings. (As a matter of fact, though, there are unintended interpretations of *any* formal mereology. So it would be a mistake to think that formal principles alone will distinguish proper-parthood from *all* other strict partial orderings. However, as we shall see, given appropriate background assumptions, there seems to be no problem in finding formal principles that distinguish proper-parthood at least from *strictly less than* and *proper divisor of*.)

[8] By the 'correlate' of (WSP) for the binary relation R, I mean the principle of the same *form* as (WSP) but applying to R instead of to proper-parthood. In other words, the correlate of (WSP) for R is the principle requiring that for all x and y, $Rxy \rightarrow \exists z(Rzy \wedge {\sim}\exists w((Rwx \vee w = x) \wedge (Rwz \vee w = z))$.

How strong are these arguments for (WSP)? If we grant Koslicki's initial claim that the lump is a proper part of the statue, are these further arguments for (WSP) strong enough to convince us that the statue has some immaterial part?

As for the first argument, I think that intuitions about the general properties of parthood relations are of limited value. It seems to me that non-philosophers have few such intuitions. I am surprised in particular at the confidence with which philosophers like Koslicki, Olson and Effingham and Robson attribute intuitive plausibility to (WSP). I myself have no intuitions whatsoever regarding the truth or falsity of (WSP). My own experience in speaking with non-philosophers about parthood is that while they may be comfortable in talking in specific contexts about the parts of specific kinds of objects (like cars or human bodies), most people have little to say about parts *in general* and do not know what to make of principles like (WSP). This is admittedly questionable evidence based on my own (possibly skewed) personal experience. Still, I think that if it is to be taken seriously, Effingham and Robson's opposing claim that (WSP) is 'in accord with our intuitions' should be supported by empirical data.

Further, it is not clear to me why we should trust those intuitions we do have regarding the formal properties of the parthood relation. For even when we restrict consideration to just material objects, principles like (WSP) are still generalizations over a complex domain, consisting of a huge number of different kinds of cases – parts of molecules, parts of organisms, parts of artefacts, and so on. I doubt that our pre-theoretical judgements are based on a fair consideration of all kinds of parts of all kinds of objects.

(WSP) does seem to have some initial intuitive appeal when Koslicki (p. 168) presents it as follows: 'if a proper part were to be subtracted from the whole of which it is a proper part, a remainder, i.e., a proper part disjoint from the first, should be left over as a result of this operation of subtraction'. But I think that this seems right only if we limit our attention to proper parts like the head or the tail of the cat statue. These and other paradigmatic examples of statue parts are all *strictly smaller than* the whole. It does make sense that if we subtract, either conceptually or by physically breaking off, a part which does not extend over the whole statue, then there should be some bit of the statue left over which is discrete from the subtracted piece. But once we allow that a whole can have a proper part which is spatially co-extensive with it, then I think that (WSP) loses its appeal. Since the lump of clay includes every bit of matter in the statue, why should we expect anything to be left over when the lump is subtracted from the statue? To put matters more vividly, I can physically subtract the tail from the statue by breaking it off and tossing it to the floor. It seems plausible that once I do this, part of the statue – all of it but the tail – is left on the mantel. By contrast, I cannot break off the lump from the statue. Moreover, if I pick up the entire lump and toss it to the floor, then no remaining part of the statue is left on the mantel. Thus the cases of *smaller parts* (like the tail) and *co-extensive parts* (like the lump) seem importantly different. It is not obvious that (WSP) retains any intuitive pull if, like Koslicki, we allow that objects have co-extensive proper parts.

My claim here is not that (WSP) is false, but just that it does not seem to have intuitive support *if we take it to apply to co-extensive proper parts*. On the other hand, (WSP) does seem more appealing if we restrict its application to parts that are strictly smaller than the whole. Let us call *x* a *smaller part* of *y* iff *x* is a part of *y* that occupies a proper subregion of *y*'s spatial region. For philosophers who hold that all parts of a material object occupy (at a time) *some* spatial region, and deny that distinct objects can occupy the *same* region, smaller-parthood just *is* proper-parthood. But for philosophers like Koslicki who hold that the statue has a distinct but co-extensive part, smaller-parthood is a proper subrelation of proper-parthood. It is crucial to Koslicki's argument that the mereological relation governed by (WSP) is proper-parthood and not smaller-parthood, otherwise this principle would not apply to the case of the lump and the statue, because the lump is *not* a smaller part of the statue. But we have just noted that given a distinction between smaller-parthood and proper-parthood, the correlate of (WSP) for the smaller-parthood relation seems to have considerably more intuitive appeal than (WSP) itself. In the next section, I will consider mereologies that postulate only some such correlate of (WSP).

I will have more to say about Koslicki's second argument for (WSP) in the next section, when this principle is considered in the context of specific mereologies. For now, I confine myself to two points. First, obviously (WSP) can serve to distinguish proper-parthood from other strict partial orderings only if (WSP) is true. So if it is doubtful whether (WSP) holds, as I think it is if proper-parthood is distinguished from smaller-parthood, then this second argument for (WSP) cannot even get off the ground. Secondly, granted that differences between proper-parthood and orderings like *strictly less than* and *proper divisor of* are to be specified formally through an account of the different logical properties of the relations, (WSP) is not the only principle that might mark these distinctions. Neither *strictly less than* nor *proper divisor of* satisfies a correlate of the following weaker principle:

QS. If *y* has any proper part, then there are objects *x* and *z* such that (i) *x* and *z* are both proper parts of *y*, and (ii) *x* and *z* share no parts.[9]

[9] See C. Gilmore, 'Why Parthood might be a Four-Place Relation, and How it Behaves if It Is', in L. Honnefelder *et al.* (eds), *Unity and Time in Metaphysics* (Berlin: de Gruyter, 2009), pp. 83–133, at p. 119 n. 45, where principle (QS), called 'quasi-supplementation', is suggested as a substitute for (WSP) if objects like the statue are taken to have co-extensive proper parts.

Moreover, principle (QS) does not seem as problematic as (WSP) does for those who hold that objects have co-extensive proper parts. For both the statue and the lump do seem to have very many pairwise discrete proper parts. I take it that, e.g., the head and the tail of the statue share no parts. In the next section, I will consider principles stronger than (QS) which might still distinguish parthood from orderings like *strictly less than* and *proper divisor of* without committing us to (WSP).

III. ALTERNATIVE MEREOLOGIES

Koslicki takes a specific mereology as a basis for her argument that material objects have immaterial parts. This theory takes the binary predicate << (interpreted as proper-parthood) as its mereological primitive. The following predicates are defined in terms of <<.

$D_{<}$. $x < y =_{df} x << y \vee x = y$ (parthood)
D_{o}. $x \circ y =_{df} \exists z(z < x \wedge z < y)$ (overlap)
$D_{\lfloor}$. $x \lfloor y =_{df} \sim x \circ y$ (discreteness)

Two axioms are assumed:

A1. $(x << y \wedge y << z) \rightarrow x << z$ (<< is transitive)
A2. $x << y \rightarrow \exists z(z << y \wedge z \lfloor x)$ (WSP)

I will call this formal theory '**WM**'. It follows from (A1) and (A2) that << is asymmetric.

T1. $x << y \rightarrow \sim y << x$ (<< is asymmetric)

Thus **WM** requires that << is a strict partial ordering.

Additional theorems of **WM** tell us that the defined relation < is reflexive, transitive, and anti-symmetric. Thus < is a partial ordering.

T2. $x < x$ (< is reflexive)
T3. $(x < y \wedge y < z) \rightarrow x < z$ (< is transitive)
T4. $(x < y \wedge y < x) \rightarrow x = y$ (< is anti-symmetric)

In particular, **WM** prohibits distinct material objects from each being part of the other. This is just what (T4) says. Accordingly, though Koslicki holds that the lump is part of the statue, she denies that the statue is part of the lump.

The axioms of **WM** are commonly presented as neutral semantic or conceptual principles. Achille Varzi claims that (WSP) and the transitivity principle express only minimal requirements 'which any relation must satisfy

... if it is to qualify as parthood at all' ('The Extensionality of Parthood', pp. 110–11). Einar Bohn takes a mereology slightly stronger than **WM** as a '*minimum* of mereological necessary truths' ('An Argument', p. 27 n. 3). Josh Parsons includes **WM** as a sub-theory of what he presents in 'Theories of Location' as a metaphysically neutral system of conceptual truths about location.

But some philosophers who distinguish between objects like the statue and its lump hold that the two co-extensive objects are each part of the other. These metaphysicians cannot endorse **WM**, since it requires that parthood is anti-symmetric. Both Simons (*Parts*, pp. 199–204) and Thomson ('Parthood', pp. 215–16) deny that the parthood relation holding among material objects satisfies an anti-symmetry principle. As we shall see shortly, by dropping the assumption that parthood is anti-symmetric, we are able to distinguish between (WSP) and a close correlate of (WSP) and construct a mereology that entails only the latter principle.

The mereology **M** takes the parthood predicate $<$ as primitive. (It turns out that proper-parthood is too weak to serve as a convenient primitive for **M**.) **M**'s two initial axioms are theorems of **WM**.

MA1. $x < x$ ($<$ is reflexive)
MA2. $(x < y \wedge y < z) \rightarrow x < z$ ($<$ is transitive)

But no counterpart of **WM**'s anti-symmetry theorem is a theorem of **M**. In particular, (T4) cannot be derived from the initial axioms (MA1) and (MA2). Because of this, the following two auxiliary relations are distinct in **M**.[10]

$D_{<<1}$. $x <<_1 y =_{df} x < y \wedge x \neq y$ (proper-parthood)
$D_{<<2}$. $x <<_2 y =_{df} x < y \wedge \sim y < x$

$<<_1$ is just proper-parthood – $<<_1$ holds between x and y if and only if x is part of y but is not identical with y. To see that $<<_2$ is distinct from $<<_1$,

[10] Aaron Cotnoir makes the same point in 'Anti-symmetry and Non-extensional Mereology', p. 398. However, his approach to this issue is different from mine. He initially leaves open the question of whether in contexts where the anti-symmetry principle is rejected, the term 'proper-parthood' should be interpreted as in ($D_{<<1}$) or as in ($D_{<<2}$). By contrast, I have stipulated from the start of this paper that the term 'proper-parthood' is used for parts which are not identical with their wholes (with the result that only ($D_{<<1}$) can function as a definition of proper-parthood in the present mereology). I agree with Cotnoir that 'proper-parthood' is sometimes defined as in ($D_{<<2}$). However, I think that ($D_{<<1}$) is the more common definition. Also, importantly, ($D_{<<1}$) captures the notion of proper-parthood which is apparently intended in Koslicki's argument. Given ($D_{<<1}$), it follows immediately from premises (1) and (2) that the lump is a proper part of the statue. If proper-parthood were instead defined as in ($D_{<<2}$), the conclusion that the lump is a proper part of the statue could only be drawn with the help of the further controversial assumption that the statue is not part of the lump. But though Koslicki denies that the statue is part of the lump, she does not introduce this claim into her argument for immaterial parts and only discusses it briefly elsewhere in her book, p. 178 n. 15.

suppose, as **M** allows, that objects *A* and *B* are such that *A* is part of *B*, *B* is part of *A*, and $A \neq B$. Then *A* stands in $<<_1$ to *B* and *B* stands in $<<_1$ to *A*, but neither object stands in the stronger $<<_2$ relation to the other (since each stands in < to the other). This case also shows that **M**'s $<<_1$ need not be asymmetric – when distinct objects *A* and *B* are part of each other, then each of *A* and *B* stands in $<<_1$ to the other. Thus, unlike **WM**, **M** does not require that the proper-parthood relation is a strict partial ordering. However, it is an immediate consequence of axioms (MA1) and (MA2) that $<<_2$ is a strict partial ordering.

Given the distinct predicates $<<_1$ and $<<_2$, and given also the *overlaps* and *discrete from* predicates defined in (D_o) and ($D_\wr$) above, there are two non-equivalent principles having the same form as **WM**'s (WSP):

WSP. $x <<_1 y \rightarrow \exists z(z <<_1 y \wedge z \wr x)$
MA3. $x <<_2 y \rightarrow \exists z(z <<_2 y \wedge z \wr x)$

The first principle is (WSP). It requires that for any proper part *x* of *y*, *y* has another proper part *z* that is discrete from *x*. I do *not* add (WSP) to **M**'s axiom set, but instead take the alternative supplementation principle (MA3) as the third axiom of **M**. Unlike (WSP), (MA3) applies only when *x* stands in the stronger relation $<<_2$ to *y*. In this case, (MA3) requires that there is an object *z* standing in $<<_2$ to *y* which is discrete from *x*. (WSP) is *not* entailed by **M**'s three axioms. Also, with the third axiom (MA3) added to (MA1) and (MA2), we still cannot derive a counterpart of **WM**'s asymmetry principle for proper-parthood, (T1), or a counterpart of **WM**'s anti-symmetry principle for parthood, (T4).

Although several authors[11] cite Simons' claim (*Parts*, p. 116) that (WSP) is 'constitutive of the meaning of "proper part" ', Simons himself assumes only a time-indexed version of (MA3) in his 'Mereology for Continuants' (CT) (pp. 177–95). Indeed, since he holds that distinct continuants may (at a time) each be part of the other, he cannot consistently endorse a time-indexed version of (WSP) for his continuant mereology. When *A* and *B* are distinct objects that are each part of the other, each is a *proper part* of the other, but neither has any proper parts that are discrete from the other.[12]

Unlike **WM**'s (WSP), **M**'s (MA3) does not prohibit proper parts that overlap every part of a whole. In this sense, (MA3) is weaker than (WSP). But (MA3) is still strong enough to distinguish $<<_2$ from strict partial orderings

[11] See Koslicki, p. 80; Effingham and Robson, p. 635; Eagle, p. 76; Casati and Varzi, p. 39.

[12] Simons' presentation in *Parts* obscures his position on this issue. He does not introduce any counterpart of $<<_1$ in his theory (CT). He defines a time-indexed version of $<<_2$ in (CT), but uses the symbol << for this predicate. Since he uses << elsewhere for proper-parthood and does not explicitly distinguish (CT)'s time-indexed version of (MA3) from (WSP), readers may overlook the fact that only the former principle is included in (CT).

like *strictly less than* and *proper divisor of*, neither of which satisfy (MA3). Thus (MA3) rules out the unintended models that Koslicki uses (WSP) to eliminate. (MA3) is another example, besides the principle (QS) from §II, of an alternative to (WSP) that seems to perform as well as (WSP) in the task at issue in Koslicki's second argument for (WSP).

Could **M** allow us to avoid the conclusion that the statue has some part which is discrete from the lump of clay? It can. But only if, unlike Koslicki, we hold that the statue and the lump are each part of the other. For if the lump were part of the statue but did not have the statue as a part, then the lump would stand in the stronger relation $<<_2$ to the statue, and like (WSP), (MA3) would require the statue to have a part that is discrete from the lump.

It is not clear to me exactly why Koslicki denies that the statue is part of the lump. In her very brief discussion of this issue (p. 178 n. 15), she says only that it is not plausible 'to attribute a part to the statue-shaped piece of clay which has the persistence-conditions of the statue-nose, as opposed to those of the nose-shaped piece of clay coincident with it'. (If the statue is part of the lump, then on the assumption that parthood is transitive, all of the statue's parts, including presumably its nose, head, etc., as well as the pieces of clay coincident with these things, are also parts of the lump.) But I do not see why Koslicki presents this as a matter of choosing between the statue-nose and the piece of clay coincident with it as the more likely part for the lump of clay. In fact, given that the lump is, on her account, part of the statue, the statue presumably has *both* the statue-nose and the nose-shaped piece of clay as its parts. If so, then the further assumption that the statue is part of the lump entails that *both* the statue-nose and the nose-shaped piece of clay are parts of the lump (not that the statue-nose is part of the lump and the nose-shaped piece of clay is *not* part of the lump). Also, given that on her account the lump is part of the statue, Koslicki cannot hold that objects generally have only parts with persistence-conditions similar to their own. The lump is part of the statue, and the persistence-conditions for the lump are very different from those of the statue. I do not see what is special about the lump that would prevent it, but not the statue, from having parts with persistence-conditions different from its own.

Nor do I see how Koslicki generalizes from the case of the statue and the lump. If in some cases of co-extensive objects *A* and *B*, *A* has *B* as a part (as the statue has the lump as a part), but in other cases *A* does not have *B* as a part (as the lump does not, on Koslicki's account, have the statue as a part), how in general do we determine whether one of two co-extensive objects is part of the other? On Koslicki's view, is it always the case that *exactly one* of two co-extensive objects has the other as a part? If so, how do we decide which one (especially in cases where both coinciding objects are artefacts, as in Sidelle's example[13] of the piece of yarn and the sweater into which it is knitted)? What about cases of non-co-extensive objects? On Kosicki's view, what is it about the nose-shaped piece of clay that qualifies it as a part of the statue while the statue-nose does not count as a part of the lump? It seems to me that we need at least a sketch of a general rule laying out the conditions under which one object counts as a part of another before we can get started on assessing the logical properties of the parthood relation.

Koslicki admits that among philosophers who distinguish between the lump and the statue, the view that co-extensive objects are each part of the other is 'widespread'. As she notes, Judith Thomson is an important advocate of the 'mutual parts' treatment of co-extensive objects.[14] In developing her own mereology for material objects, Thomson is guided by the following understanding of the parthood relation for material objects: *x* is part of *y* if and only if the space occupied by *x* is included in the space occupied by *y*.[15] On this picture of parthood, it follows immediately that the lump and the statue are each part of the other and also that the statue-nose, statue-tail, and so on, as well as the bits of clay making up these statue parts, are all parts of both statue and lump. Further, when parthood is treated as spatial inclusion, **M**'s strict partial ordering $<<_2$ is interpreted as the relation that holds between *x* and *y* if and only if the space occupied by *x* is a proper subregion of the space occupied by *y*. In other words, $<<_2$ is interpreted as the *smaller part* relation, which, as I argued earlier, has a stronger intuitive claim to satisfy a supplementation principle in the spirit of (WSP) than does Koslicki's *proper part* relation. Thus Thomson's account of the parthood relation supports the principle (MA3) but not (WSP). As a result, Thomson can agree with Koslicki that the lump is a proper part of the statue, while avoiding Koslicki's conclusion that the statue has immaterial parts.

[13] A. Sidelle, 'A Sweater Unraveled: Following One Thread of Thought for Avoiding Coincident Entities', *Noûs*, 32 (1998), pp. 423–48.

[14] Simons' position here is interesting, but not fully worked out in *Parts*, and too complex to address in this paper. He seems to favour allowing for parthood relations of different strengths, the weakest of which would hold between *x* and *y* if and only if *x*'s matter is included in *y*'s matter (pp. 247–51). I tend to think that Simons' weakest parthood relation amounts to the same thing as Thomson's spatial inclusion reading of parthood. In any case, it is a sense of parthood according to which the lump and the statue are each part of the other (since the two objects are made of the same matter).

[15] See, e.g., 'The Statue and the Clay', p. 155. Thomson presents this analysis of parthood as a time-indexed biconditional, and develops a time-relative mereology for material objects. Again because the temporal relativity of parthood is not pertinent to the current discussion, I ignore it. Thomson also assumes that each object occupies exactly one spatial region whenever it is present. When I discuss Effingham and Robson in §IV, I shall show that parthood relations become more complicated if we allow that objects may occupy multiple spatial regions at a single time.

In fact, given the spatial inclusion reading of parthood, we seem justified in adopting a stronger principle than (MA3). The so-called 'strong supplementation principle' (SSP) requires that if x is not part of y, then x has a part which is discrete from y (see Simons, p. 29).[16]

SSP. $\sim x < y \rightarrow \exists z(z < x \wedge z \lfloor y)$

On the spatial inclusion reading, (SSP) tells us that if x is not spatially included in y, then x has a part that does not spatially overlap y. This seems plausible: if my bust of Julius Caesar is not spatially included in the hunk of marble making up the bulk of the bust (because, say, the bust includes some gold overlay that extends a bit beyond the marble), then the bust should have parts (here, bits of gold) which are discrete from the marble. Thus the spatial inclusion reading of parthood seems to support a stronger mereology than **M**.

Let $\mathbf{M}^+$ be the mereology that takes the parthood predicate as primitive and has (MA1), (MA2), and (SSP) as axioms. Since (MA3) is a theorem of $\mathbf{M}^+$, $\mathbf{M}^+$ is strictly stronger than **M**. I suggest that proponents of the spatial inclusion reading of parthood might endorse $\mathbf{M}^+$ even if they allow, as both Thomson and Koslicki do, that objects have co-extensive proper parts. The mereology $\mathbf{M}^+$ is neither stronger nor weaker than **WM**. **WM** includes theorems which are not derivable in $\mathbf{M}^+$ – for example, (WSP). But $\mathbf{M}^+$ includes important theorems – for example, (SSP) – which are not derivable in **WM**.[17]

[16] In his otherwise excellent paper 'Mereology without Weak Supplementation', *Australasian Journal of Philosophy*, 87 (2009), pp. 505–11, Donald Smith makes the misleading claim (p. 507) that '(WSP) is entailed by the strong supplementation principle'. If this were so, then we could not endorse (SSP) without also embracing (WSP). In fact, although (WSP) can be derived from the combination of (SSP) and the anti-symmetry principle for parthood, (WSP) does not follow from (SSP) alone. It is trivial to verify that the two-member model whose object domain is $\{A, B\}$, and where $\{\langle A, A\rangle, \langle B, B\rangle, \langle A, B\rangle, \langle B, A\rangle\}$ is the extension of the parthood relation, satisfies (SSP) and all axioms of **M**, but not (WSP).

[17] Besides (SSP), the following useful principle is a theorem of $\mathbf{M}^+$, but not of **WM**:

$\mathrm{M^+T1}$. $\forall z(z \circ x \rightarrow z \circ y) \rightarrow x < y$

($\mathrm{M^+T1}$) says that if every object overlapping x also overlaps y, then x is part of y. This principle is useful because it lets us derive claims about parthood from information about overlap. Thus, e.g., given that the statue and the lump overlap the same objects, ($\mathrm{M^+T1}$) tells us that each is part of the other. By contrast, in models of **WM**, complete information about the overlap relation does not alone suffice to fix the extension of the parthood relation.

There are other non-equivalent ways of strengthening **M** besides adding (SSP) to it. The result of supplementing the axioms of **M** with the principle (QS) from §II is a theory that is strictly stronger than **M**, but in which neither (WSP) nor (SSP) cannot be derived. Alternatively, the result of supplementing **M** with the following axiom (guaranteeing the existence of a difference of y in x, if x is not part of y)

$$\sim x < y \rightarrow \exists z \forall w\, (w < z \leftrightarrow w < x \;\wedge\; w \lfloor y)$$

is a theory that is strictly stronger than $\mathbf{M}^+$, but in which (WSP) still cannot be derived.

At the end of her book, Koslicki (p. 262) invites the sceptical reader to pinpoint exactly where her argument goes wrong in using (WSP) together with Leibniz's law to derive her conclusion that the statue has immaterial parts. I suggest that we might disagree with her conclusion regarding immaterial parts, while still agreeing with the first three premises of her argument (stating that the lump is distinct from the statue and part of the statue and so a proper part of the statue) as well as with her assumption that the parthood relation conforms to some principle which is both intuitively plausible and strong enough to distinguish parthood from orderings such as (*strictly*) *less than* or (*proper*) *divisor of*. We might do so by embracing any of the following three alternative mereological strategies:

(A) Adopt **WM**, the mereology that Koslicki assumes as a basis for her argument, but interpret its primitive as *smaller part* rather than as *proper part*. I argued in §II that if the *smaller part* relation is distinct from the *proper part* relation, then the correlate of (WSP) for smaller-parthood seems to have better intuitive support than does (WSP). This correlate of (WSP) would still serve to exclude the non-mereological interpretations Koslicki wants to rule out. To my mind, the only drawback of this strategy is that if we retain WM's definition ($D_<$) of parthood, we would have to say that neither the lump nor the statue is part of the other (since neither is a *smaller part* of the other, and by assumption they are distinct).

But we could replace ($D_<$) with a more complex definition of parthood. We might define x to be a part of y if and only if either x is identical with y, x is a smaller part of y, or x has some smaller part and all of x's smaller parts are also y's smaller parts. Parthood remains reflexive and transitive, but need not be anti-symmetric.[18] We could then retain Koslicki's assumption that the lump is part of the statue as long as we hold (as seems reasonable) that all of the smaller parts of the lump are also smaller parts of the statue.

If we wish, we might even follow Koslicki in maintaining that the statue is *not* part of the lump. With the suggested new definition of parthood, this would be so if and only if the statue has smaller parts – perhaps the statue-nose and other structural parts of the statue – which are not also smaller parts of the lump. (On this alternative approach, smaller-parthood cannot be construed as proper spatial inclusion, since then the statue-nose, together with the other smaller parts of the statue, would all also be smaller parts of the lump. So if this more complicated approach is taken, we should expect a clear statement of the criterion used to determine which objects are smaller parts of which others.)

[18] More precisely, if in **WM** ($D_<$) is replaced by ($D_<$*) $x < y =_{df} x = y \vee x << y \vee [\exists z(z << x) \wedge \forall z(z << x \rightarrow z << y)]$, then (T4) is no longer a theorem of the mereology.

(B) Adopt the weaker mereology **M** and interpret the parthood predicate in a way that makes the lump and the statue each part of the other. Here we might follow Thomson in treating parthood as spatial inclusion. If so, **M**'s $<<_2$ is interpreted as smaller-parthood and (MA3) has roughly the same intuitive support as the supplementation principle assumed in strategy (A). As noted above, **M**'s (MA3) is still strong enough to exclude the undesirable orderings.

(C) Adopt either **M+** or one of the alternative stronger mereologies mentioned in fn. 17 above, interpreting the parthood predicate as in strategy (B). This approach gets us a mereology which has some formal advantages over **WM** but still allows us to deny that the statue has any part which is discrete from the lump.

IV. MEREOLOGY AND METAPHYSICS

I agree with Koslicki that the claim that some objects have spatially co-extensive proper parts is at least compatible with (though perhaps not dictated by) ordinary thinking about parts and wholes. True, in everyday discourse, we do not generally explicitly distinguish between objects like statues and their constituting lumps of stuff. But neither do we explicitly affirm that statues are identical with their constituting lumps of stuff. As far as I can tell, ordinary thinking is neutral on this issue, not addressing at all the dilemma posed by different ways of tracing objects like statues and lumps that can be formed of the same matter.

But if common sense does not rule out spatially co-extensive proper parts, then it is not obvious that (WSP), rather than, say, only **M**'s (MA3), is embedded in our ordinary notion of parthood. As I argued above, only the weaker principle seems intuitively plausible if we allow that objects may have co-extensive proper parts.

More generally, given that everyday thinking about the parts of objects rarely involves even moderately complicated reasoning (and almost never explicitly invokes principles governing parthood), it is not obvious exactly what set of mereological principles are underwritten by ordinary intuitions. For this reason, I think we should be cautious in assuming that a specific mereology, **WM** or even just **M**, is somehow built into our notion of parthood and so is a presupposition of any metaphysical theory of objects.

The further point that I would now like to make is that when we leave the realm of the everyday and extend our discussion to patently unfamiliar configurations of objects, we should be especially cautious before concluding that otherwise appealing mereological principles still apply. This point is relevant for the use of mereological principles in metaphysical arguments, because these arguments are often framed in contexts that allow for unexpected arrangements of objects. As mentioned in §I, the arguments of Effingham and Robson and Eagle assume that objects can travel through time in a way that allows one object to be located at multiple positions at a single time. Olson applies (WSP) in a context which leaves open the possibility that ordinary enduring objects are comprised of arbitrarily many short-lived temporal parts. Whatever one's philosophical position on temporal parts or the possibility of time travel, it certainly does not occur to the ordinary person (or the philosopher in an ordinary mood) that the parts of, say, a table may include a series of instantaneous table-sized objects, or that multiple copies of the same part may be situated at different positions in the table (so that, e.g., what looks like four distinct legs is actually *one* table part, a time-travelling leg that has been carried to the present moment several times and fastened to each of the four corners of the top). Since ordinary thinking does not take such exotic cases into consideration, it should not be surprising that a principle might seem plausible when considered in the light of prototypical cases of parthood, but still fail in the exotic cases.

The focus of Effingham and Robson's 'A Mereological Challenge' is an example involving a single time-travelling brick B, which is repeatedly taken backwards in time and positioned in such a way that at a designated time **t**, B is lined up next to, on top of and under itself so as to compose a wall W. Effingham and Robson point out that (WSP) appears to fail in this sort of case. To see why, note that although B is in a sense smaller than W (B is just a brick and not a whole wall), because B is multiply located throughout W it extends across the whole of W at **t**. It follows then, just as it does in the case of non-time-travelling co-extensive proper parts like the lump and the statue, that B overlaps each part of W at **t**. Thus although B is a proper part of W at **t**, no proper part of W at **t** is discrete from B at **t**.

In Effingham and Robson's example, every copy of B at **t** is included in the only copy of W at **t**. The extent to which the possibility of backwards time travel unhinges ordinary thinking about parthood is brought out even more clearly when we consider variations on the original example which allow for a more complex and ambiguous relation between B and W at **t**. Suppose that after B single-handedly composes W at **t**, other bricks gradually replace B at each of its positions in W. By some time **t***, B and W are each still present, but B is no longer part of W. Now suppose that after **t***, B or W (or both) are brought *again* to **t** and arranged so that one of the following holds: (i) some, but not *all*, of B's locations at **t** are included in W's only location at **t** (on its last run back to **t**, B is tossed 50 yards from W and the other copies of itself at **t**); (ii) B is included in some, but not *all*, of W's locations at **t** (the B-free version of W that emerges from **t*** is hauled back to **t** and set across from the B-saturated copy of W at **t**); (iii) some, but not *all*, of B's locations at **t** are included in some, but not *all*, of W's locations at **t** (both B and the B-free version of W are brought back to **t** and distributed to diverse locations).

I think that it is not clear how the familiar temporal notion of parthood is supposed to apply in these more complex scenarios. For example, in scenario (i), B seems to retain *some* claim to still counting as a part of W at **t**: B still single-handedly composes the only copy of W at **t**. But since one copy of B at **t** lies at some distance from W and is entirely independent of W, it is not obvious that B still qualifies as a part of W at **t**. We ordinarily assume that by, say, lifting an object *y* at time *t*, we thereby lift all of *y*'s parts at *t*. But in scenario (i), we could lift W at **t** without in any way affecting one copy of B. I think it is worth considering whether the *ordinary* temporalized notion of parthood transfers to these time travel scenarios at all. If the assumption that each object occupies at most one place at a time is a prerequisite of its use, then perhaps ordinary parthood-at-a-time must be replaced in time travel contexts by a corresponding relation which shares *only some* of the familiar relation's properties.

As I understand him, in his 'Mereological Explanation', Effingham operates under the assumption that given the possibility of multi-location at a time, object *x* counts as a part of object *y* at time *t* as long as *some* copy of *x* at *t* is included in *some* copy of *y* at *t*. On this rather weak conception of parthood-at-a-time, B would count as a part of W at **t** in each of scenarios (i)–(iii). As Effingham himself points out, given backwards time travel, this temporalized parthood relation not only violates (WSP), but also fails the (time-indexed) transitivity principle. For suppose the copy of B lying 50 yards from W in scenario (i) includes a particle of clay which is not included in any of the copies of B composing W at **t**. Then on Effingham's weak notion of parthood at a time, this particle is part of B at **t** (a copy of the particle is included in *one* copy of B at **t**) and B is part of W at **t**, but the particle is not part of W at **t** (no copy of the particle is included in the only copy of W at **t**). Thus the temporalized parthood relation appropriate for time travel contexts may not satisfy even (time-indexed versions of) the axioms of **M**. If so, then the possibility of backwards time travel challenges more of the standard theoretical assumptions about parthood than does the possibility of spatially co-extensive proper parts.

In their original paper 'A Mereological Challenge', Effingham and Robson present their brick example as a reason for preferring a metaphysical theory, perdurantism, which allows us to retain a fundamental parthood relation satisfying favoured principles like (WSP) even in the time travel cases. (If B and W were construed as four-dimensional objects and the fundamental parthood relation were taken to be an *atemporal* relation which holds between *x* and *y* only if *x*'s entire spacetime path is included in *y*'s spacetime path, then B would *not* count as a part of W, and consequently would not violate (WSP), in any of the scenarios presented above.) Instead, I think the time travel cases illustrate only the modest and unsurprising point that when we allow drastic changes in ordinary restrictions on the arrangement of objects in spacetime, we should expect corresponding changes in structural relations like *parthood*, *next to*, *above* and *below*. The assumption that the *next to* relation is irreflexive – that no object may lie next to itself – is surely more clearly embedded in common sense thinking than is the assumption that parthood satisfies (WSP). But the set-up of Effingham and Robson's original example requires that objects like the time-travelling brick may lie next to, *and* above *and* below, themselves at a time. (Otherwise, B could not be stacked up in the appropriate way to form a wall at **t**.) Just as it would be silly to revise our metaphysics in order to retain a *next to* relation with all of the usual properties in time travel cases, so also it seems unwarranted to prefer a metaphysical position *only* because it lets us hang onto a parthood relation with all of the properties we attributed to parthood before we took time travel into consideration.

Koslicki's own final thesis, that material objects have immaterial structuring principles as parts, is another example of a metaphysical position which clashes with ordinary assumptions about objects and their parts, and so calls for a re-evaluation of otherwise appealing mereological principles. The average person would list four legs and a top, but *not* a special structuring principle for tables (nor, I think, any other immaterial entities), as parts of my iron patio table. It is not obvious that principles which hold for ordinary parts like table legs still remain valid if tables have also immaterial structuring principles as parts. Unlike familiar material parts, the immaterial principles do not spatially divide objects by occupying subregions of the whole object's spatial extent. Thus, unlike material parts, structuring principles might be shared by spatially separated objects or spatially separated parts of the same object. For example, on Koslicki's view, my table's four legs and top all have an iron-atom-structuring principle (inherited by transitivity from their atomic parts) as a part. If a single iron-structuring principle is a *shared* part of all iron atoms, then contrary to ordinary assumptions, the spatially separate material parts of the table overlap.

In this setting, it is not obvious that (WSP), or even the weaker (MA3), holds. Whether these principles hold or not depends on issues surrounding formal parts (whether the immaterial parts stand to one another in parthood relations, or whether the immaterial parts are universal and so are shared by all objects with the same structure) which are not considered in common sense thinking. (Koslicki herself officially leaves open the question of whether the structuring principles are universal or individual, but leans towards the former position. She says (p. 257) that she finds 'individual forms as well as haecceities to be puzzling entities', and goes on to wonder what could distinguish the forms of two structurally isomorphic statues.) Thus even if principles like (WSP) or (MA3) do hold within Koslicki's metaphysical theory, ordinary intuitions about objects and their parts cannot verify that they do. What is needed here, before we can settle on an appropriate mereology, is a new account of parthood which extends over both formal and material parts in a way that fits the general constraints of Koslicki's theory.

I said in §II that one of Koslicki's central arguments for (WSP) is that this principle is needed to distinguish proper-parthood from strict partial orderings, whose structures might seem to be quite different from that of the parthood relation. This argument for (WSP) owes much to Simons, *Parts*, 1.1, which presents a series of Hasse diagrams to motivate (WSP) and other mereological principles. Each diagram is taken to represent a structure that we may (or may not) want our mereology to exclude, depending on how well the diagram fits our intuitive picture of the parthood relation. For example, Simons (pp. 27–8) uses the diagram in Fig. 1 to motivate (WSP). As with the *proper divisor of* relation, all individuals in the domain of the strict partial ordering represented in it overlap.[19] Simons seems to think it obvious that this diagram clashes with our intuitive picture of parthood. He presents it only to dismiss it immediately, saying 'A moment's thought shows that this too cannot be a model of part and whole. What we have here is a universe all of whose parts overlap each other. But surely if a universe is complex (i.e., has proper parts at all), then at least two of these parts will be disjoint.'[20] As with *proper divisor of*, the relation represented above violates its correlate of (WSP).

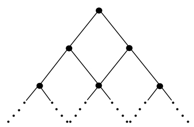

Figure 1

[19] They do not all share *one* common part, as the integers share *one* common proper divisor. But any two individuals (represented by the nodes of the diagram) share some common part which may be found by tracing far enough down the diagram. In this respect, the structure of the partial ordering represented in Simons' diagram is similar to that of the converse of the *proper divisor of* relation. This is the *proper multiple of* relation which holds between positive integers *j* and *k* if and only if *k* is a multiple of *j* other than *j* itself. Though there is no one common multiple shared by *all* positive integers, any two positive integers, *n* and *m*, have infinitely many common multiples, including *nm*, 2*nm*, 3*nm*, ...

[20] Cody Gilmore points out in 'Why Parthood might be a Four-Place Relation' that this particular intuition, that a complex universe must have *some* disjoint parts, is captured by the weaker principle (QS) listed in §II. We might thus preserve Simons' intuition without going so far as to endorse (WSP).

Simons takes it as a point in favour of (WSP) that it distinguishes parthood from orderings like that of this Hasse diagram.

But whether the relation between material objects and their parts looks like *strictly less than*, *proper divisor of*, or any of the partial orderings represented in Simons' Hasse diagrams, depends on what sorts of parts objects have and on how these parts are arranged in the world. Suppose, for example, that objects do have formal parts and that all structurally identical objects share common formal parts. Suppose further that these formal parts are themselves divided into parts in such a way that one formal part *f* is part of another formal part *g* if the condition for being present in the world which *f* imposes must be satisfied whenever *g*'s condition is satisfied. Then there could plausibly be some common part of all formal parts – perhaps a formal part representing a very general condition, like being self-identical or occupying a spatiotemporal region.[21] If so, this universal formal part would be a common part of *all* material objects and their (material and immaterial) parts. The proper-parthood relation would then have a structure similar to our token 'unmereological' partial ordering, *proper divisor of*, and both (WSP) and (MA3) would fail.

As another example, suppose that objects travel backwards through time in a way that allows one object to be located at arbitrarily many spatial positions at a time. Then it is at least possible that *all* currently present objects share the same time-travelling particle-part (imagine a wandering particle that single-handedly manages to compose *every* object at a given time) or at least that any two currently present objects have some common particle-part. Again all objects would overlap, and parthood would have a structure similar to that of either the *proper divisor of* relation or the partial ordering represented in the Hasse diagram above.

In his response to Effingham and Robson, Donald Smith presents the issues surrounding parthood and time travel as 'an instance of how metaphysics can shape formal mereology', and concludes ('Mereology without Weak Supplementation', p. 510) that 'the extent to which one is inclined to admit or dismiss the possibility of an object's being multiply-located at a single time dictates the extent to which one is inclined to deny or accept principles such as (WSP)'. I concur, as also does Effingham in his later paper 'Mereological Explanation and Time Travel' (p. 636), at least where Smith's point applies to the time-indexed version of (WSP). I have tried to show that this point applies generally. Which mereological principles we endorse should depend on what stances we take on a range of metaphysical issues, including time travel, formal parts and material coincidence.

[21] Paul Hodva makes this suggestion in his review of Koslicki's book, in *Notre Dame Philosophical Reviews* (2009).

My suggestion is that instead of assuming from the outset either specific mereological principles or intuitively appealing (or unappealing) abstract models of parthood, we first need some general rules (even if only sketchy ones) placing limits on the arrangement of objects in the world and on the conditions under which objects have parts. For example, returning to Judith Thomson's strategy, one possibility is to construe *x* as a part of *y* at time *t* if and only if some location of *x* at *t* is included in a location of *y* at *t*. (This particular treatment of parthood rules out immaterial parts in so far as these are not spatially located.) Given the further assumption that distinct objects like the statue and its constituting lump share a location at a time, then as I pointed out in §II, parthood satisfies neither the time-indexed version of (WSP) nor the time-indexed anti-symmetry principle. On the other hand, as long as each object or object part occupies *exactly one* spatial region whenever it is present (so that there is no multi-location at a time), parthood may reasonably be taken to satisfy the time-indexed version of the strong supplementation principle (SSP).

Alternatively, if we adopt Thomson's spatial inclusion reading of parthood and retain the prohibition on multi-location at a time, but now add a further assumption *prohibiting* location sharing, then we might reasonably conclude that parthood satisfies, besides (SSP), also (time-indexed versions of) the axioms of **WM**, including (WSP). In both cases, the satisfaction of (WSP) or (SSP) depends not only on how many locations a single object may have at a time and on whether objects may share locations, but also on the distribution of parts to the smaller subregions of objects' locations. Elsewhere I work through these issues in detail, introducing classes of mathematical models in which objects' locations are represented as sets of points in spacetime and parthood is represented using the set inclusion relation.[22] Given different restrictions on the distribution of objects' locations in the models (capturing assumptions about whether objects can share locations, have multiple locations at a time, and so on), it is straightforward to prove that the parthood relation in the models either satisfies or fails to satisfy correlates of (WSP), (SSP), and other mereological axioms. Here, importantly, conclusions about the logical properties of parthood are *not* based on pre-theoretical assessments of isolated models, as in Simons. Instead, a class of models as a whole represents an infinite range of possibilities for the parthood relation, given explicit background restrictions on spatiotemporal location and on the conditions under which one object is part of another.

Things are more complicated if we allow that objects may have formal parts or multiple locations at a time. In either case, the parthood relation for

[22] See M. Donnelly, 'Parthood and Multi-Location', in D. Zimmerman (ed.), *Oxford Studies in Metaphysics*, Vol. v, pp. 203–43.

material objects does not match up in a straightforward way with the inclusion relation on the spatial regions at which objects are located (in the former case, because the formal parts are not spatially located; in the latter case, because even at a fixed time objects need not have unique spatial locations). But since our intuitive understanding of parthood takes neither formal parts nor time travel into consideration, it is especially important that proponents of such exotic possibilities should construct an appropriate alternative account of parthood, instead of merely assuming that otherwise appealing mereological principles remain valid in the new setting.

V. CONCLUSION

I have argued that we should be cautious in our use of mereological principles to support metaphysical claims. In the first place, it is not obvious exactly which mereological principles, e.g., (WSP) or only the weaker (MA3), are embedded in our ordinary way of thinking about parts and thus are somehow constitutive of our notion of parthood. Secondly, certain metaphysical claims seem to unhinge the background assumptions of ordinary thinking about parts and wholes to such an extent that it is doubtful whether the ordinary mereological notions transfer intact to situations governed by those claims.

My overall conclusion is that unless we make appropriate minimal background assumptions about the way objects are arranged in the world (e.g., that objects have only material parts and cannot share a spatial location or have more than one location at a time), we have little reason to endorse principles like (WSP). For this reason, it seems best to develop a theory of parts and wholes in conjunction with more substantial metaphysical theses. Because it is not obvious that any plausible metaphysical theory must espouse principles like (WSP) or the transitivity principle for parthood, I see no reason to assume that any useful core mereology – **WM** or even the weaker **M** – functions as a common basis for *all* plausible metaphysical theories.[23]

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