Composition and the Logic of Location: An Argument for Regionalism

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Ned Markosian (2014) has recently defended a new theory of composition, which he calls *regionalism*: some material objects xx compose something if and only if there is a material object located at the fusion of the locations of xx. Markosian argues that regionalism follows from what he calls the *subregion theory of parthood* (STP). Korman and Carmichael (2016) agree. We provide countermodels to show that regionalism does not follow from (STP), even together with fourteen potentially implicit background principles. We then show that regionalism does follow from five of those background principles together with (STP) and two additional principles connecting parthood and location, which we call (Overlap) and (Strong Delegation). While the additional principles are not uncontroversial, our conjecture is that many will find them attractive. We conclude by mentioning that (Strong Delegation) fills a previously unnoticed gap in the formal theory of location presented in Parsons (2007).

1. Introduction

Ned Markosian (2014) defends a new answer to the *special composition question*: Under what circumstances do several material objects compose something? Markosian's new answer is *regionalism*: 'Necessarily, for any xs, there is a y composed of those xs iff there is a region, r, and an object, z, such that r is the fusion of the regions occupied by the xs and z occupies r' (2014: 82).[1] According to regionalism, some material objects compose something if and only if a material object is located at the fusion of their locations. For example, two hydrogen atoms and an oxygen atom compose something if and only if some material object (a water molecule, perhaps) is located at the fusion of those atoms' locations.

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[1] Markosian adds that regionalism should be understood as entailing the ground-theoretic thesis that if some material objects compose something, then they compose something *in virtue of the fact that* some material object is located at the fusion of their locations (2014: 83). However, as he notes, he argues only for the simpler, non-ground-theoretic thesis. We too will set ground theory aside. Our results here are necessary preliminaries to any argument for the ground-theoretic thesis.

Regionalism is consistent with a number of more familiar answers to the special composition question. This is because for any particular things xx regionalism doesn't tell us whether a material object is located at the fusion of the locations of xx.[2] Markosian's own view is that composition 'occurs sometimes but not always'. To use his example: the particles that make up your brain do compose something (your brain), but your brain and Jeremy Bentham's body do not compose anything. Regionalism is consistent with this because it is consistent with the thesis that though there is a material object (your brain) located at the fusion of the locations of your brain's particles, there is no material object (not even a scattered object) located at the fusion of the locations of your brain and Bentham's body. Regionalism is also consistent with universalism about composition, the view that for any material objects xx, some y is composed of xx. In fact, regionalism is consistent even with nihilism, the view that no complex objects exist.

One might complain (with Korman and Carmichael 2016) that this makes regionalism uninformative. Again, regionalism doesn't tell us which regions have complex material objects located at them and thus doesn't tell us whether any particular objects compose a further object. However, we think that regionalism is nevertheless an important thesis and that it is worthwhile to articulate the best argument for it. Unlike the more familiar answers to the special composition question, regionalism tells us something about complex material objects, their parts, *and* their locations. Since the familiar extant theories of composition say nothing about location, none of them guarantees both regionalism's necessity direction (that if some material objects xx compose something, then a material object is located at the fusion of the locations of xx) and its sufficiency direction (that if a material object is located at the fusion of the locations of material objects xx then xx compose something).[3]

But both directions are tempting. Consider necessity. If material objects xx compose something, y, it is plausible that some material object is located at the fusion of the locations of xx, namely, y! Where else would y be? Two miles to the left? Platonic Heaven? Now consider the sufficiency direction. If a material object y is located at the fusion of the locations of material objects xx, many will insist that xx must compose something, namely, y. How could y be so located without being composed of xx?

Even if regionalism does not settle the dispute between the nihilist, the moderate, and the universalist, it is an attractive thesis in its own right, and it imposes mereological and locational constraints on the more familiar theses. So we think that anyone who is interested in composition ought to be interested in what an argument for regionalism would need to look like.

Markosian argues that regionalism follows from what he calls the *subregion theory of parthood* (STP): for any material objects x and y, 'x is a part of y iff the region occupied by x is

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[2] Regarding terminology, our notation for plural variables is 'xx', etc., whereas Markosian's is 'xs', and we use 'material object' as a synonym for Markosian's 'physical object'.

[3] Universalism does entail the sufficiency direction, by entailing that composition always occurs. Nihilism, together with the assumption that every material object has a location, entails the necessity direction, by entailing that if material objects xx compose y, then each of xx is identical to y.

a subregion of the region occupied by y' (2014: 73).[4] As we will see, regionalism is ambiguous between two natural readings. We will show that on neither reading does regionalism follow from (STP); on one reading, neither direction of regionalism follows from (STP). After we provide the countermodels that establish this, we set out a new argument that yields both versions of regionalism. The new argument relies on (STP) but also on several additional principles, some of which have been discussed in the literature. These additional principles are not uncontroversial. However, we conjecture that many will find them suitable for use in an argument for regionalism.

2. Preliminaries

We begin by setting out some assumptions and definitions. We use the language of plural logic, supplemented with a primitive two-place predicate for exact location, '$x@y$', and primitive one-place predicates for regionhood, 'Rx', and material objecthood, 'Mx'. We give the standard gloss of exact location: a material object x is exactly located at a region y just in case x has the same size and shape as y and bears the same distance relations to things as does y. For example, if o is a material object that is cubical, 1 cubic meter in volume, and 2 meters from object o*, then o is exactly located at a region r only if r is also cubical, 1 cubic meter in volume, and 2 meters from o*.[5]

We also invoke a primitive two-place predicate, '$x \leq y$', for parthood (being a proper-or-improper part of), together with predicates for proper parthood, overlapping, and disjointness, all defined in the usual ways: for x to be a proper part of y ('$x < y$') is for x to be a part of but not identical to y; for x to overlap y ('$x \circ y$') is for something to be a part of both x and y; and for x and y to be disjoint ('$x \wr y$') is for x and y to not overlap. We take our parthood predicate to apply univocally both to material objects and to regions, but everything we say could be restated in terms of a parthood predicate for material objects and a subregionhood predicate for regions. We formalize (STP) as follows:[6]

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[4] Markosian (2014: 82-83) attempts a two-part proof of regionalism from (STP). In note 13 we identify the misstep.

[5] While talk of distance relations between points is straightforward, talk of distance relations between non-point-sized things is less so. But we hope that our gloss has some content and gives the reader a sense of the intended meaning of our primitive. (Others who treat exact location as a primitive and gloss it roughly as we do include Casati and Varzi (1999), Gibson and Pooley (2006), Gilmore (2006), Sattig (2006), Balashov (2010), Donnelly (2010), Saucedo (2011), Effingham (2015), and Lafrance (2015).) More informative characterizations can be given, but at a cost. For example, Parsons (2007) invokes a primitive notion of *weak location*, glossed as, 'x is weakly located at y iff y is not completely free of x'. He uses this primitive to define exact location: for x to be exactly located at y is for x to be weakly located at all and only those entities that overlap (share a part with) y. This definition entails that if x is exactly located at r and also at s, then r and s overlap exactly the same things, which friends of multilocation (e.g., Sattig 2006) deny. However, our argument for regionalism rules out multilocation anyway, since it relies on Functionality (see §3). So there is no harm in appealing to Parsons's characterization as a fallback option, for those who find our initial gloss of exact location insufficiently informative.

[6] A more literal translation of Markosian's principle into our formal language is (STP*):

$(Mx \wedge My) \rightarrow$

$$(x@r \land y@s) \rightarrow (x \leq y \leftrightarrow r \leq s) \tag{STP}$$

(If x is located at r and y located at s, then x is a part of y iff r is a part of s.)[7] (STP) is an 'alignment' principle, in Saucedo's (2011) terminology. It requires a kind of mirroring between, on one hand, the mereological relations between objects and, on the other, the mereological relations between the locations of those objects.[8] We follow Markosian (and van Inwagen (1990)) and define 'y is composed of xx' as:

$$yCxx =_{df} \forall w \forall z((w \prec xx \land z \prec xx \land w \neq z) \rightarrow w \wr z) \land$$

$$\forall z(z \prec xx \rightarrow z \leq y) \land \forall z(z \leq y \rightarrow \exists x(x \prec xx \land z \circ x)) \tag{Composition}$$

(y is composed of $xx =_{df}$ (i) every two of xx are disjoint, (ii) each of xx is a part of y, and (iii) each part of y overlaps at least one of xx.) As we mentioned, regionalism is ambiguous. Markosian frames the view in terms of *fusions* of regions. But there are different definitions of 'fusion' and Markosian does not say which he intends. So we will distinguish two versions of regionalism. The first version results from taking 'is a fusion of' to be synonymous with 'is composed of':

$$(\forall x(x \prec xx \rightarrow Mx) \land \forall w \forall z((w \prec xx \land z \prec xx \land w \neq z) \rightarrow w \wr z)) \rightarrow$$

$$(\exists y(yCxx) \leftrightarrow \exists z \exists r \exists ss(rCss \land Mz \land z@r \land \forall x(x \prec xx \rightarrow \exists s(s \prec ss \land x@s)) \land$$

$$\forall s(s \prec ss \rightarrow \exists x(x \prec xx \land x@s)))) \tag{$\text{Reg}_{CC}^{\leftrightarrow}$}$$

(If each of xx is a material object and every two of xx are disjoint, then something is composed of xx iff there is a z, an r, and some ss such that (i) r is composed of ss, (ii) z is a material object, (iii) z is located at r, (iv) for each x that is one of xx, there is an s that is one of ss such that x is located at s, and (v) for each s that is one of ss, there an x that is one of xx such that x

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is located at s.) [9] Less formally, (Reg$_{CC}^{\leftrightarrow}$) says that if xx are disjoint material objects ('$DMxx$'), then: xx compose something ('$CSxx$') iff some material object is located at something that is *composed* of those objects' locations ('$LCxx$'). In short: $DMxx \rightarrow (CSxx \leftrightarrow LCxx)$.

The second version of regionalism, which we call (Reg$_{CF}^{\leftrightarrow}$), results from replacing the second occurrence of 'C' in the formal statement of (Reg$_{CC}^{\leftrightarrow}$) with a fusion predicate 'F' defined as follows:

$$yFxx =_{df} \forall z(z \prec xx \rightarrow z \leq y) \ \wedge \ \forall z(z \leq y \rightarrow \exists x(x \prec xx \wedge z \circ x)) \qquad \text{(Fusion)}$$

So defined, fusion is weaker than composition. From the claim that y is composed of xx, it follows that y is a fusion of xx. However, it follows from the former claim, but not from the latter claim, that no two of xx overlap. (Henceforth, unless we explicitly say otherwise, by 'fusion' we will mean the notion defined by (Fusion).) Informally, (Reg$_{CF}^{\leftrightarrow}$) says that if xx are disjoint material objects, then: xx compose something iff some material object is located at something that is a *fusion* of those objects' locations ('$LFxx$'): $DMxx \rightarrow (CSxx \leftrightarrow LFxx)$.

Each version of regionalism is logically equivalent to a conjunction of two weaker principles, one offering necessary conditions for material composition, the other offering sufficient conditions. It will be convenient to have names for the four weaker principles. To minimize tedious formalism, we introduce them all at once, in abbreviated form:

		Necessary condition for material composition		Sufficient condition for material composition
(Reg$_{CC}^{\leftrightarrow}$)	equivalent to conjunction of	**(Reg$_{CC}^{\rightarrow}$)**: $DMxx \rightarrow (CSxx \rightarrow LCxx)$	and	**(Reg$_{CC}^{\leftarrow}$)**: $DMxx \rightarrow (CSxx \leftarrow LCxx)$
		$\Downarrow$		$\Uparrow$
(Reg$_{CF}^{\leftrightarrow}$)	equivalent to conjunction of	**(Reg$_{CF}^{\rightarrow}$)**: $DMxx \rightarrow (CSxx \rightarrow LFxx)$	and	**(Reg$_{CF}^{\leftarrow}$)**: $DMxx \rightarrow (CSxx \leftarrow LFxx)$

The weaker principles result from replacing the biconditional double-arrow in the formal statements of (Reg$_{CC}^{\leftrightarrow}$) and (Reg$_{CF}^{\leftrightarrow}$), respectively, with a single arrow (a material conditional or a converse material conditional, '$\leftarrow$', as the relevant names indicate). The most important thing to

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[9] Three points. First, the first clause in the antecedent is included because regionalism is only meant to supply conditions for *material objects* (not, say, *regions*) to compose something. Second, regarding the second clause of the antecedent, we follow Markosian, who writes that '[r]egionalism needs to be qualified so that it says "for any *non-overlapping x*s . . ."' (2014: 82, note 26, emphasis original), in light of the disjointness clause in (Composition). Third, regarding (*ii*), we include it for the sake of explicitness, but given our assumption (and Markosian's) that only material objects have locations, it is redundant.

see at this stage is that since fusion is weaker than composition, ($\mathrm{Reg}_{CC}^{\leftarrow}$) is weaker than ($\mathrm{Reg}_{CF}^{\leftarrow}$), but ($\mathrm{Reg}_{CC}^{\rightarrow}$) is stronger than ($\mathrm{Reg}_{CF}^{\rightarrow}$).

Before moving on, we should note that at least two additional definitions of fusion commonly appear in the literature.[10] These definitions are equivalent to (Fusion), given classical mereology, on which see Hovda (2009). While we will not assume classical mereology, we will make some assumptions about regions, which we take to be implicit in Markosian's discussion, that have a similar effect. Given these assumptions, the two additional versions of regionalism that result from the additional definitions of fusion are both equivalent to ($\mathrm{Reg}_{CF}^{\leftrightarrow}$). So we will not give them separate treatment.[11]

3. Countermodels

Markosian (2014) and Korman and Carmichael (2016) claim that regionalism follows from (STP). In fact, neither ($\mathrm{Reg}_{CC}^{\leftrightarrow}$) nor ($\mathrm{Reg}_{CF}^{\leftrightarrow}$) follows from (STP), even together with a generous collection of background principles that might be implicit in Markosian's discussion.

We divide the background principles into four groups. The principles in the first group, which constitute what Varzi (2016) calls *Extensional Mereology*, apply unrestrictedly to all entities, including regions and material objects.

Extensional Mereology (EM)

(1) $x \leq x$ (Reflexivity)

Everything is a part of itself.

(2) $(x \leq y \land y \leq z) \rightarrow x \leq z$ (Transitivity)

If x is a part of y, and y is a part of z, then x is a part of z.

(3) $(x \leq y \land y \leq x) \rightarrow x = y$ (Anti-symmetry)

If x is a part of y, and y is a part of x, then $x = y$.

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[10] Our definition of 'fusion', which we take from from Lewis (1991), is what Hovda (2009) calls a 'Type-2 fusion', framed in plural logic. What Hovda (2009) calls 'Type-1 fusion' can be framed in plural logic as: y is a T1-fusion of xx iff: for all z, z overlaps y iff z overlaps one of xx. Finally, the minimal upper bounds (MUB)-style definition, in plural logic, is: y is a MUB-fusion of xx iff each of xx is a part of y and for all z, if each of xx is a part of z, then y is a part of z. (For useful discussion, see Cotnoir 2016.) In the presence of assumptions (1) – (5) and (12) in the main text below, the versions of regionalism that result from interpreting 'F' as T1-fusion or as MUB-fusion are equivalent to ($\mathrm{Reg}_{CF}^{\leftrightarrow}$). We omit the proof.

[11] Fine (2010) and Kleinschmidt (forthcoming) argue, on different grounds, that 'fusion' is primitive and 'part' is defined. We lack the space to discuss how this shift would affect our project.

(4)　　$\sim x \le y \rightarrow \exists z\,(z \le x \land z \wr y)$　　　　　　　　　　(Strong Supplementation)

> If x is not a part of y, then x has some part z that is disjoint from y.

Like classical mereology, EM entails that no plurality has more than one fusion. (Proof omitted.) But whereas classical mereology entails that every plurality has at least one fusion, EM leaves that question open. Thus, unlike classical mereology, EM avoids prejudging the answer to the special composition question.

The principles in the second group, which Markosian (2014: 86) seems to endorse, connect parthood with regionhood.

Parts and Regions (PAR)

(5)　　$(x \prec xx \rightarrow Rx) \rightarrow \exists y[yFxx \land \forall z(zFxx \rightarrow Rz)]$　　　　　(R-Fusion)

> If each of xx is a region, then: there is at least one fusion of xx and any fusion of xx is a region.

(6)　　$(x \le y \land Ry) \rightarrow Rx$　　　　　　　　　　　　　　(Regional Parts)

> Any part of a region is a region.

PAR guarantees that every plurality *of regions* has at least one fusion. Together with EM, this entails that every such plurality has *exactly* one fusion. This leaves it open whether every plurality of material objects has a fusion.[12]

The principles in the third group concern regionhood, material objecthood, and their interaction with each other and with parthood.

Material Objects and Regions (MOR)

(7)　　$[(x \prec xx \rightarrow Mx) \land yFxx] \rightarrow My$　　　　　　　　　　(M-Fusion)

> If each of xx is a material object and y is a fusion of xx, then y is a material object.

(8)　　$\sim(Rx \land Mx)$　　　　　　　　　　　　　　　　(Exclusivity)

> Nothing is both a region and a material object.

(9)　　$(x \le y \land My) \rightarrow Mx$　　　　　　　　　　　　　(Material Parts)

> Any part of a material object is a material object.

These principles enforce a kind of dualism about material objects and regions.

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[12] Although PAR plays no role in Markosian's argument or ours, we include it to make it explicit that even if it is assumed, Markosian's argument remains invalid. (R-Fusion) does however play a role in securing the equivalence of the additional versions of regionalism (mentioned in note 10) to $(\text{Reg}_{CF}^{\leftrightarrow})$.

The principles in the fourth group, which we take to be endorsed by Markosian and in some cases implicit in his argument, concern location and its interaction with material objecthood and regionhood.

Material Objects, Regions, and Location (MRL)

(10) $Mx \rightarrow \exists y(x@y)$ (Exactness)

Each material object has a location.

(11) $\exists y(x@y) \rightarrow Mx$ (Objecthood)

Only material objects have locations.

(12) $\exists x(x@y) \rightarrow Ry$ (Regionhood)

All locations are regions.

(13) $(x@y \wedge x@z) \rightarrow y = z$ (Functionality)

Nothing has more than one location.

(14) $(x@y \wedge z@y) \rightarrow x = z$ (Anti-Colocation)

No two entities share a location.

MRL bans non-located material objects, multilocated entities, distinct co-located entities, and locations that are non-regions. It does not ban non-located entities in general, nor does it ban regions at which nothing is located.

Note that MRL says nothing about parthood. In particular, it says nothing about how the mereological properties of or relations between some objects must mirror the mereological properties or relations between the locations of those objects. Making these 'mirroring' requirements precise is the job of alignment principles such as (STP), which we treat as foreground, not background.

With (1) – (14) in place, we turn to our models. Each model is specified by a Hasse-style diagram. In each diagram, the solid nodes represent the material objects in the model and the hollow nodes represent the regions in the model. A straight upward-running line connecting a node n to a higher node m represents n being a proper part of m. The downward-pointing arrows represent the higher node being located at the lower node. Keep in mind that a model need not correspond to a possible or even conceivable situation to make the desired point, which in each case is the purely logical point that a given sentence is a not a logical consequence of certain other sentences.

First we provide a model in which (STP) and (1) – (14) are true but ($\text{Reg}_{CF}^{\leftarrow}$) and ($\text{Reg}_{CC}^{\rightarrow}$) are false.
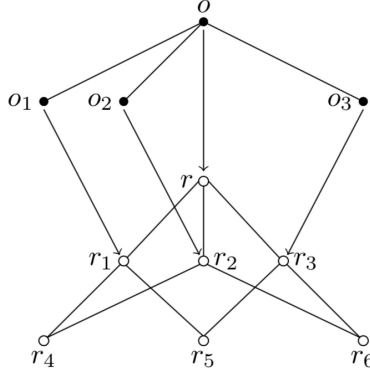
Figure 1

In this model, the complex material object o is composed of the simple material objects o_1, o_2, and o_3. o_1 and o_2 do not compose anything. o is located at r, o_1 is located at r_1, o_2 is located at r_2, and o_3 is located at r_3. As the reader can check, (STP) is satisfied in the model. For any case in which x is located at s_1 and y is located at s_2, x is a part of y iff s_1 is a part of s_2. $(1) - (14)$ are also satisfied in the model, as the reader can also check. But while r is a fusion of the locations of o_1 and o_2, and there is a material object located at r in the model, o_1 and o_2 do not compose anything, so $(\text{Reg}_{CF}^{\leftarrow})$ is not satisfied. Though note that the model is not a countermodel to $(\text{Reg}_{CC}^{\leftarrow})$: r is a *fusion* of r_1 and r_2, but r_1 and r_2 do not *compose* r, since they are not disjoint.

It is also important to see that $(\text{Reg}_{CC}^{\rightarrow})$ fails in the model. The material objects o_1, o_2, and o_3 do compose something, o, but no material object is located at something their locations compose. Their locations, which overlap each other, do not *compose* anything. Though note that $(\text{Reg}_{CF}^{\rightarrow})$ still holds: there is a material object located at r, which is the *fusion* of the locations of o_1, o_2, and o_3. So, whether we disambiguate regionalism via (Composition) or via (Fusion), our first model shows that regionalism does not follow from (STP) together with $(1) - (14)$.

The distinctive feature of the model is that, although it satisfies (STP), it violates a similar-looking alignment principle:

$$(x@r \land y@s) \rightarrow (x \circ y \leftrightarrow r \circ s) \tag{Overlap}$$

(If x is located at r and y located at s, then x overlaps y iff r overlaps s.) In the model, o_1's location overlaps the locations of o_2 and o_3, but o_1 overlaps neither o_2 nor o_3. It is tempting to assume that (Overlap) follows from (STP), but the above model shows that it does not. In fact, the two principles are logically independent, as noted by Uzquiano (2011).

We now provide a countermodel showing that neither $(\text{Reg}_{CC}^{\rightarrow})$ nor $(\text{Reg}_{CF}^{\rightarrow})$ follows from (STP) and $(1) - (14)$.
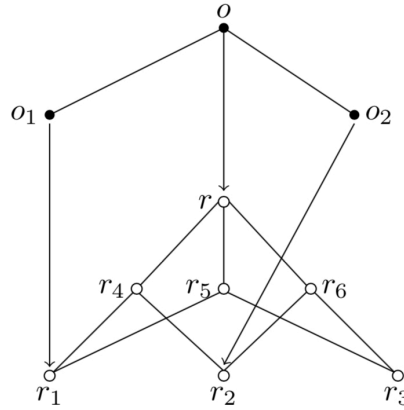
Figure 2

In this model, there are exactly three material objects. o_1 and o_2, are simple, and o is complex: its parts are itself, o_1, and o_2. o_1 is located at r_1, o_2 is located at r_2, and o is located at r, which is composed of r_1, r_2, and r_3. As the reader can check, (STP) and $(1) - (14)$ are all satisfied in the model, as is (Overlap). Objects o_1 and o_2 compose something. Yet nothing is located at the region that is composed of – and fuses – their locations, r_4. So neither $(\text{Reg}_{\overrightarrow{CC}})$ nor $(\text{Reg}_{\overrightarrow{CF}})$ is satisfied.[13]

The distinctive feature of this model is that although it satisfies (STP), $(1) - (14)$, and (Overlap), it violates certain 'delegation' principles (so named by Gilmore (2009), (2018)).[14] Delegation principles are alignment principles that say, roughly, that complex objects fill up their locations by delegation: if r is the location of a complex object o, then no part of r is filled by o alone, without the help of some proper part ('delegate') of o. (To *fill* a region, let us say, is to have a location that has the given region as a part.) The delegation principle that will be our focus here is:

$$(\exists y (y < x) \land x@r) \rightarrow$$

$$\forall yy(xFyy \rightarrow \forall r'(r' \leq r \rightarrow \exists s \exists y'(y' < yy \land y'@s \land r' \circ s))) \qquad \text{(Strong Delegation)}$$

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[13] This shows that Markosian's attempt to derive the necessity direction of regionalism from (STP) must go wrong somewhere but does not specify where. For those who are interested, here is the relevant passage from Markosian:

> First we assume . . . STP. Then we also assume of some randomly chosen xs that there is an object composed of those xs. . . . Call the object composed of the xs A. It follows immediately from STP plus the fact that A is composed of the xs that [M1] *every one of the xs occupies a subregion of the region occupied by A*. But from the fact that the xs compose A we also know that [M2] *there is no part of A that fails to overlap at least one of the xs*. So we know that [M3] *the region occupied by A is the fusion of the regions occupied by the xs*.' (2014: 83, italics added).

As our model shows, M3 does not follow from M1 and M2.

[14] Kleinschmidt (forthcoming) motivates her claim that 'fusion' is primitive in part by its ability to rule out similar scenarios, informally described. But the purely mereological system that results does not block our second model, so it seems that some delegation principle will still be needed.

(If x is complex and is located at r, then for any yy of which x is a fusion, each part r' of r overlaps a location of one of yy.) Two comments. First, the idea is not that *all* objects must fill their locations by delegation. That would rule out simple material objects that have complex, extended locations. (For defenses of such objects, see Markosian (1998), Parsons (2000), and Simons (2004).) Second, our second model does violate (Strong Delegation). The object o is complex and is a fusion of o_1 and o_2, but there is a part, r_3, of o's location that does not overlap a location of o_1 or of o_2.

One final remark about our models. We have stated (1) – (14) explicitly, and noted that our models satisfy all these principles, to dispel worries about the relevance of those models. The fact that the models satisfy (1) – (14) shows that those models target only the most relevant aspects of the argument. They do not trade on exotic possibilities about the behavior of parthood, as it applies to material objects or as it applies to regions. They do not appeal to distinct fusions of the same plurality, or failures of unrestricted fusion for regions, or multilocation, or distinct co-located entities, or non-located material objects. The only 'funny business' in the models is their violation of certain alignment principles. So, even against the background of a well-behaved parthood relation and a separately well-behaved location relation, (STP) is not strong enough to deliver regionalism. Further alignment principles, ensuring that parthood and location interact as expected, are required.[15]

4. The new argument

Recall that there are two versions of regionalism on the table: $(\text{Reg}_{CC}^{\leftrightarrow})$ and $(\text{Reg}_{CF}^{\leftrightarrow})$. To prove that both versions follow from our premises, we will prove the stronger sufficient condition, $(\text{Reg}_{CF}^{\leftarrow})$, and the stronger necessary condition, $(\text{Reg}_{CC}^{\rightarrow})$. The countermodels discussed earlier satisfied (1) – (14). However, our argument will only rely on five such principles. We will refrain from invoking some of the more controversial principles, such as (Anti-Symmetry), (Strong Supplementation), (Exclusivity), (Objecthood), or (Anti-Colocation). Nor will we invoke (Transitivity), (R-Fusion), (Regional Parts), or (Regionhood), which are widely taken to be innocuous.

4.1 Premises

We will show that $(\text{Reg}_{CC}^{\leftrightarrow})$ and $(\text{Reg}_{CF}^{\leftrightarrow})$ are logical consequences of (STP), (Reflexivity), (M-Fusion), (Material Parts), (Exactness), and (Functionality), together with (Overlap) and (Strong Delegation), and an instance of the plural comprehension schema of plural logic. As attractive as

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[15] We have allowed that (1) – (14) might be implicit premises in Markosian's argument. Why haven't we allowed that (Overlap) and (Strong Delegation) might be implicit premises too? First, even if (Overlap) and (Strong Delegation) are implicit premises, our models still show that regionalism does *not* follow from the set {(STP), (1) – (14)}, which was not antecedently obvious. Second, (Overlap) and (Strong Delegation) are more similar to (STP) than to any of (1) – (14). Like (STP), and unlike (1) – (14), they are alignment principles that govern the interaction of parthood and location. So, given that Markosian takes pains to make (STP) explicit, it seems that if (Overlap) and (Strong Delegation) were meant play a role in the argument, they would have been made explicit as well.

these premises may be, they are not uncontroversial, and some objections to them are worth highlighting.

First, as Markosian notes, some think that it is possible for material objects (e.g., bosons) to interpenetrate without overlapping, like a ghost and a wall. (See Sanford (1967) and Gilmore (2018) for further references and discussion.) This would generate counterexamples to (Overlap) and (STP). Second, as Uzquiano (2011: 205) notes, even if one rejects ghost/wall-style interpenetration, one might think that disjoint, topologically closed material objects can be in perfect contact and have locations that share boundary points as common parts. This is inconsistent with (Overlap). Third, Gilmore (2006), Parsons (2007), Kleinschmidt (2016), and (Leonard 2014; 2018) note that in the context of non-standard models of space, one might think that a material object could fail to have an (exact) location. This is inconsistent with (Exactness).[16] Fourth, some (e.g., Sattig 2006) think that material objects are multilocated. (See Donnelly (2010) and Gilmore (2018) for discussion.) This is inconsistent with (Functionality). Fifth, some (e.g., McDaniel (2001), Koslicki (2008)) think that some material objects have, as parts, 'formal components,' such as tropes or universals, that are not material objects. This is inconsistent with (Material Parts). Sixth, according to Cartwright (1975) and Uzquiano (2006), material objects can only be located at topologically open regions. Consider an open spherical object o located at open spherical region r. o is a fusion of two open hemispherical objects, o_1 and o_2, located at r_1 and r_2. Centerpoint p of r does not overlap r_1 or r_2 but is a part of r. This is inconsistent with (Strong Delegation).

So the argument will not carry weight with everyone. We suspect, however, that many will find the premises plausible. In any event, our goal is to chart connections, not to proselytize. Having shown that Markosian's argument is invalid, we seek further premises – the more plausible, the better – that would suffice to fill the gaps. Friends of the premises acquire a new route to regionalism; skeptics come to see how hard it is to repair Markosian's argument. Everyone learns something.

4.2 Proof of validity

Our proof comes in two steps: in the first we prove ($\text{Reg}_{CF}^{\leftarrow}$); in the second we prove ($\text{Reg}_{CC}^{\rightarrow}$).

Step one. Recall that we abbreviated ($\text{Reg}_{CF}^{\leftarrow}$) as: $DMxx \rightarrow (CSxx \leftarrow LFxx)$. So, to prove this principle, we will consider some arbitrary things that satisfy 'DM' and 'LF', and we will show that they must satisfy 'CS' as well. Let xx be arbitrary material objects each two of which are disjoint, and which are such that there is a z, an r, and some ss, such that (a) r is a fusion of ss, (b) z is a material object, (c) z is located at r, (d) for each x that is one of xx, there is an s that is one of ss such that x is located at s, and (e) for each s that is one of ss, there is an x that is one of xx such that x is located at s. We need to show that something y is composed of xx. We will do this by showing that z itself is composed of xx. Given the definition of composition,

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[16] These authors actually discuss a related principle: if x is weakly located somewhere, then x is exactly located somewhere. But their cases also threaten our principle.

we need to check that three conditions hold: (i) each two of xx are disjoint; (ii) each of xx is a part of z; and (iii) every part of z overlaps at least one of xx.

Condition (i). This is true by hypothesis.

Condition (ii). Consider an arbitrary a that is one of xx. By (d), a is located at something, call it s^*, that is one of ss. Then, since r is a fusion of ss, it follows by the definition of fusion that s^* is a part of r. But since a is located at s^*, z is located at r, and s^* is a part of r, it follows by (STP) that a is a part of z. But a was arbitrary, so condition (ii) is true.

Condition (iii). Assume for *reductio* that there is a part of z, call it x', that doesn't overlap any of xx. By (Material Parts), we know that x' is a material object. So by (Exactness), we know that x' must have a location, say, s'. By hypothesis we know that z is located at r. So z is located at r and x' is located at s' and x' is a part of z, from which it follows by (STP) that s' is a part of r. We also know, by hypothesis, that r is a fusion of ss. By the definition of fusion, then, any part of r overlaps at least one of ss. Recall s' is a part of r. So s' overlaps one of ss. But if s' overlaps one of ss (which by hypothesis is a location of one of xx), then by (Overlap) we know that x' overlaps at least one of xx, which contradicts our initial assumption and completes our *reductio*. Therefore, condition (iii) holds. Since conditions (i)-(iii) hold, ($\mathrm{Reg}_{CF}^{\leftarrow}$) is true.

Step two. Now we turn to ($\mathrm{Reg}_{CC}^{\rightarrow}$), which we abbreviated as: $DMxx \rightarrow (CSxx \rightarrow LCxx)$. Consider arbitrary material objects xx each two of which are disjoint and an arbitrary y composed of xx. We need to show that there is a z, an r, and some ss such that five conditions hold: (i) r is composed of ss, (ii) z is a material object, (iii) z is located at r, (iv) for each x that is one of xx, there is an s that is one of ss such that x is located at s, and (v) for each s that is one of ss, there an x that is one of xx such that x is located at s.

Since each of xx is a material object, by (Exactness), each of xx has a location. Since something is a location of one of xx, by (Plural Comprehension)[17] we know that there are some things that are all and only the locations of one or another of xx.[18] Call these things ss^*. So: each of xx is located at one of ss^*, and each of ss^* is such that one of xx is located at it, which means that xx and ss^* jointly satisfy (iv) and (v).

We can turn now to conditions (i), (ii), and (iii). We know that y is composed of xx. Hence we know, by the definitions of composition and fusion, that y is a fusion of xx. We also know that each of xx is a material object. It follows, by (M-Fusion), that y is a material object. So, by (Exactness) and (Functionality), we know that y has exactly one location, call it L_y. We'll show that L_y is composed of ss^*, which will secure conditions (i), (ii), and (iii) and complete our proof.

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[17] (Plural Comprehension): $\exists x \varphi(x) \rightarrow \exists yy \forall z (z \prec yy \leftrightarrow \varphi(z))$; if something is φ, there are some things yy such that for all z, z is one of yy iff z is φ.

[18] We substitute '$\exists x'(x' \prec xx \wedge x'@x)$' for '$\varphi(x)$' in (Plural Comprehension).

We know that y is composed of xx, hence that (a) each of xx is a part of y. We also know that (b) y is located at L_y. Finally, we know that (c) for each of ss^*, one of xx is located at it. Together with (STP), (a) – (c) entail that (d) each of ss^* is a part of L_y. So, in order to show that L_y is composed of ss^*, it will suffice to prove two more things, namely, that (e) each part of L_y overlaps at least one of ss^*; and that (f) each two of ss^* are disjoint. We will prove (e) by cases, of which there are two.

Case one: y does not have any proper parts. In other words, every part of y is identical to y. So, given that xx compose y – and hence each of xx is a *part* of y – it follows that each of xx is *identical* to y. So each of the locations of xx – i.e., each of ss^* – is identical to a location of y. We already know that there is exactly one location of y, namely, L_y. So each of ss^* is identical to L_y. Trivially, each part of L_y overlaps L_y. (This is guaranteed by (Reflexivity) and the definition of 'overlap'.) So, each part of L_y overlaps at least one of ss^* (namely, L_y). This means that (e) holds.

Case two: y has at least one proper part. Then, since y has a location (namely, L_y), the antecedent of (Strong Delegation) is satisfied, and we can conclude that (g) for any things zz of which y is a fusion and for any u, if u is a part of L_y then u overlaps a location of one of zz. Now let s' be an arbitrary part of L_y. Since y is a fusion of xx, and L_y is a location of y, and s' is a part of L_y, by applying (g) we get the result that s' overlaps a location of one of xx; that is, s' overlaps one of ss^*. Since s' was arbitrary, we can conclude that each part of L_y overlaps at least one of ss^*: (e) holds.

So, whether y has any proper parts or not, each part of L_y overlaps at least one of ss^*. Given our earlier result that each of ss^* is a part of L_y, it follows that L_y is a *fusion* of ss^*. Now, to show that L_y is *composed* of ss^*, all that remains is to prove that (f) each two of ss^* are disjoint.

Assume for *reductio* that (f) is false, i.e., that there are non-identical but overlapping entities among ss^*: call them s_i and s_j. Since s_i and s_j are among ss^*, we know that one of xx, call it x_i, is located at s_i, and that one of xx, call it x_j, is located at s_j. Since s_i and s_j are non-identical, we know by (Functionality) that x_i and x_j are non-identical. Since x_i and x_j are located at s_i and s_j, respectively, and s_i and s_j overlap, it follows by (Overlap) that x_i and x_j overlap as well. But this contradicts our assumption that each two of xx are disjoint. So we can conclude that (f) is true: each two of ss^* are disjoint. It follows that L_y is composed of ss^*.

We started with some arbitrary material objects xx and an arbitrary y composed of xx, and we showed that there is there is a z (specifically, y) an r (specifically, y's location, L_y), and some ss (specifically, xx's locations, ss^*) such that five conditions hold: (i) r is composed of ss, (ii) z is a material object, (iii) z is located at r, (iv) for each of xx is located at one of ss, and (v) each of ss is a location of one of xx. Since xx and y were arbitrary, (Reg$_{\overrightarrow{CC}}$) follows.

5. Conclusion

We first showed that neither version of regionalism follows from (STP), even together with (1) – (14). We then showed that both versions of regionalism follow from a different collection of premises, which includes (Overlap) and (Strong Delegation).

We close by noting a further application of (Strong Delegation). The influential theory of location presented in Parsons (2007)[19] is satisfied by our second model. This shows, we think, that Parsons's theory is too weak. Though the theory may be *true*, it is not the whole truth about the logic of location. Any comprehensive formal theory of location should block our second model. The theory of Casati and Varzi (1999: 122) blocks the model with an axiom equivalent to (Arbitrary Partition): if x is located at r and $r*$ is a part of r, then there is a part of x that is located at $r*$. However, since (Arbitrary Partition), together with (Functionality), rules out simple objects with complex, extended locations, which Parsons (2000), (2007) and Markosian (1998) want to allow, they reject (Arbitrary Partition). Without it, they are left with nothing to rule out our second model. We offer (Strong Delegation), which blocks that model but is friendly to simple objects with complex, extended locations.[20] [21]

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[19] Specifically, the system, call it **S@+**, that results from supplementing what Parsons calls **S@** with what he calls *Expansivity*: $[(x \leq y \wedge x@r) \rightarrow \exists s(y@s \wedge r \leq s))]$. **S@** takes parthood and exact location as primitives and contains six axioms: the Asymmetry and Transitivity of *proper* parthood; Weak supplementation $[x < y \rightarrow \exists z(z < y \wedge z \wr x)]$; Maximal common part $[x \circ y \rightarrow \exists z \forall w(w \circ z \leftrightarrow (w \leq x \wedge w \leq y))]$; (Functionality).

[20] Neither Casati and Varzi nor Parsons seek to rule out disjoint objects with overlapping locations, so they will see no need for a principle that blocks our first model. They will be skeptical of the right-to-left directions of the biconditionals in (STP) and (Overlap).

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