The Multi-location Trilemma

Damiano Costa and Claudio Calosi

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To the memory of Josh Parsons

1 Introduction

Can a single entity have more than one *exact location*? In other words, is multi-location possible? On the one hand, several metaphysical theories require it to be possible for a single entity to be exactly located at several regions.

Realists about so-called *immanent* universals,[1] for example, usually require them to be located whenever and wherever they are exemplified, so that a single universal turns out to be exactly located at several regions of space and time (Armstrong, 1978; Bigelow, 1988; Paul, 2002, 2006, 2012; Gilmore, 2006 and *pace* Effingham, 2015). Three-dimensionalists about persistence tend to spell out their view[2] as a view according to which objects persist by being wholly present/exactly located at several regions of time or spacetime (Gilmore 2006; Sattig, 2006; Donnelly, 2010).

As a matter of fact, these are the two prominent examples that both friends and foes of multi-location invoke as a reason to take multi-location seriously.

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[1] At least some of them. See §4.

[2] At least some of them. See footnote 12.

On the other hand, multi-location is undeniably problematic. Problems of multi-location are diverse: is it paradoxical (Barker and Dowe, 2003)? Does it conflict with basic mereological principles (Hawley, 2009)? And so on. And diverse are the solutions to those problems. In this paper we focus on one such problem which we find particularly pressing (§2). We shall review one proposal to solve the problem due to Antony Eagle (§3) and assess it (§4, §5). We might as well foreshadow our conclusion. The problem still stands. We then address the prospects for multi-location theorists (§6).

2 The Trilemma

The one outstanding problem we just mentioned is represented by what we shall call the *Multilocation Trilemma*, which originates in (Parsons, 2007). To appreciate it we need to introduce, at least roughly, two locative notions. One such notion is the notion of *exact location* we already mentioned. The following is a classic informal gloss on exact location:

"[A]n entity *x* is exactly located at a region *R* if and only if *x* has (or has-at-*R*) exactly the same shape and size as *R* and stands (or stands-at *R*) in all the same spatial or spatiotemporal relations to other entities as does *R*" (Gilmore, 2018, §2 -notation changed).[3]

[3] Exact location is thus understood by many philosophers. Notable examples are e.g. Casati and Varzi (1999), Hudson (2001), Sattig (2006), Hawthorne (2008), and Donnelly (2010).

In other words: objects and their exact locations share all their relevant geometrical and spatio-temporal properties and relations. The other notion is that of *weak location*. Weak location is "location in the weakest possible sense" (Parsons, 2007: 203). An entity *x* is weakly located at region *R* iff *R* is not entirely free of *x*. As an illustration: we are weakly located at our shared office, in UK, where our hands are, and so on. As one of us sticks his arm outside the office in the corridor, he is weakly located in the corridor as well. On the other hand, the red chair in front of us is exactly located at the chair-shaped region of space where it fits exactly.

A friend of multi-location faces the following trilemma: (i) she can take exact location as a primitive, or (ii) she can define it by means of weak location,[4] or (iii) she can take both exact and weak location as undefined primitives. If exact location is taken as a primitive, a principle called *Exactness* follows, according to which anything that has a weak location has an exact location too. This is problematic in that the principle rules out scenarios that should not be ruled out.[5] If exact location is defined in terms of weak location using Parsons's definition in Parsons (2007), a principle called *Functionality* follows, according to which nothing can have more than one exact location. Clearly *Functionality* amounts to the denial of multi-location. If both exact and weak location are taken as undefined primitives, the resulting theory has the metaphysically expensive consequence that it makes some plausible principles brute necessities.

[4] A possibility that Parsons does not consider -nor do we- is that exact location can be defined using other locative notions as primitives, such as e.g. *entire* or *pervasive* location.

[5] See Parsons (2007: §3). See also Gilmore (2018).

For example, the principle that anything that has an exact location has also a weak location -the converse of *Exactness*- is a principle that is a conceptual truth in the Parsons's own system, for it follows from the definitions of either exact or weak location, while no such explanation is possible if both exact and weak location are taken as primitives (Leonard, 2014).[6]

Friends of multi-location can pursue different strategies to get out of the trilemma. They might want to take exact location as a primitive and learn to live with *Exactness*. This is problematic: counterexamples to *Exactness* are convincing.[7] They might develop a theory of location with two primitives and

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[6] Kleinshmidt (2016) argues that, in any event, no theory of location that uses only one primitive can account for all the metaphysically possible scenarios.

[7] Let us review putative counterexamples to *Exactness*. We do this in a long footnote so as not to disrupt the flow of the main argument. Failures of *Exactness* might arise as a result of the mismatch between the mereological structure of objects and space. Suppose you have atomic point-particles but space is gunky, i.e. every region of space admits of further proper parts. A case in point would be Whiteheadean space (Gruszczynski and Pietuszczak, 2009; Leonard, Forthcoming). These point-like particles would not have any exact location. Yet they would certainly be somewhere in space, that is, they would be weakly located somewhere. Thus, they would violate *Exactness*.

As for another example, say that an object is *omnipresent* iff it is weakly located at every region. And say that space is junky iff every region is a proper part of yet another region. Then, omnipresent objects in junky space would violate *Exactness*. The argument goes roughly as follows. Suppose an omnipresent object, call it *oo*, has an exact location, *r*. Then *r* is the maximal region, i.e. the fusion of all regions of space. To see this, suppose *r* is not the maximal region. Then there is a region *s* that is disjoint from *r*, such that *oo* is not weakly located at *s*. But this goes against our assumption that *oo* is omnipresent. So, if *oo* has an exact location *r*, then *r* is the try to mitigate its costs. We are not aware of any developed attempt in this direction.

Finally, multilocation theorists can try to find definitions of exact location in terms of weak location that do not imply *Functionality*. In a series of publications, Antony Eagle (2010, 2016a, 2016b) has presented and defended one such definition. Eagle's attempt is important and should be thoroughly discussed, in that it is the only available proposal on the market of theories of location which promises to escape the trilemma effectively, and thus to make sense of the spatiotemporal profile of universals and three-dimensional persisting objects. And yet, *it has not been*. The aim of this paper is to provide such a discussion, thus filling the gap in the literature. In the end, we conclude that there are reasons to think that Eagle's definition is unsatisfactory.[8]

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maximal region. On the other hand, junky space rules out the existence of such a maximal region. So *oo* does not have any exact location in junky space. Yet it has a weak location. As a matter of fact, it is weakly located everywhere. This constitutes another counterexample to *Exactness*.

Finally, and to our mind most convincingly, counter-examples to *Exactness* come from quantum mechanics. Consider the following passage by Bokulich: "In other words, while it makes sense to talk about the particle having the property of position (that is to say the particles are in the room), that property cannot be ascribed a definite (precise) value" (Bokulich, 2014: 467). The passage above suggests that quantum particles can have a weak location without thereby having an exact location, thus violating *Exactness*.

[8] Perhaps there are two ways of looking at what's at stake here. On the one hand, one can maintain that Parsons and Eagle are giving two *different characterizations of the same notion*. On the other hand, one can see Eagle as trying to define a *different locative notion* that is absent from Parsons' system. This is an overall interesting suggestion, but developing it goes beyond the scope of this paper. It is important to note that the main point of the paper would still go through

The importance of this discussion goes beyond the fate of Eagle's own attempt: in (i) providing a diagnosis of *why* this attempt fails, it (ii) undermines recent proposals that crucially depend on such an attempt, such as e.g. the conditional defense of three-dimensionalism in Daniels (2014), and also (iii) provides us with a privileged standpoint from which to re-evaluate the problematic nature of multi-location and the progress we made to keep problems of multi-location at bay. Finally, Eagle (2019) explores different consequences of taking weak location as a primitive notion. The arguments in this paper go in the same direction. They explore some metaphysical consequences of taking weak location as a primitive and adopting Eagle's definition of exact location in its terms.

3 Eagle's Way Out of the Trilemma

Let us begin by presenting Eagle's definition of exact location. Eagle starts with the notion of *occupation*. He stipulates that an entity occupies a region iff the entity can, in whole or in part, be found at that region. On the one hand, if an entity can be found in a region, that region is not completely free of that entity. On the other hand, if a region is not completely free of an entity, the entity can – in whole or in part – be found at that region. Hence, we take Eagle's occupation to correspond to Parsons's weak location.

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in any case. The locative notion that Eagle defines, being it the same notion that Parsons had in mind or a different one, the one that we will label **Exact Location 2**, is the notion that allegedly supports the possibility of multilocation. And the main argument in the paper is that this is in fact not the case.

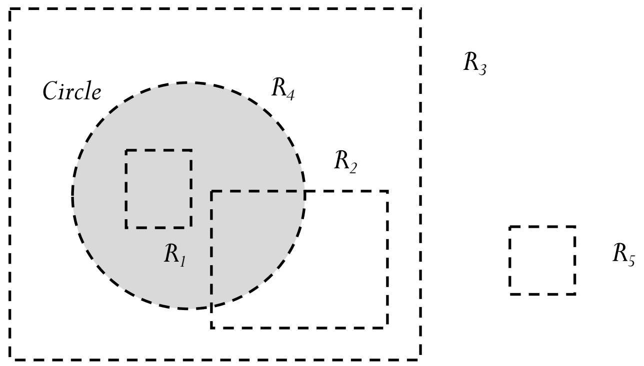

Fig.1

For example, the round entity in Fig.1, call it *Circle*, occupies regions R_1, R_2, R_3 and R_4, but not R_5. Then Eagle defines the notion of *containment* and *filling*:

> **Containment.** *O* is contained in *R* iff each part of *O* occupies a subregion of *R*.
>
> **Filling.** *O* fills R iff each subregion of *R* is occupied by *O*.

In the previous figure, *Circle* is contained in R_3 and R_4, but not in R_1, R_2 or R_5, for some of its parts are outside such regions. Moreover, *Circle* fills R_1 and R_4, but not R_2, R_3 or R_5, for some of their subregions are free of *Circle*. With these two notions in hand, one may be tempted to define exact location along the following lines (Eagle 2010, 56; Eagle 2016a: 511-512):[9]

[9] The terminology in Eagle (2016a) is slightly different.

Exact location 1. An exact location of *O* is any region *R* that both contains *O* and is filled by *O*.

This definition would do for *Circle* in Fig.1. Indeed, its only intended exact location, R_4, is the only region that both contains and is filled by *Circle*. However, this definition would create problems in *some* cases of multi-location. Consider the case[10] of a three-dimensional object that persists throughout an interval $T = (t_1\text{-}t_n)$.[11] It is three-dimensional, and therefore not temporally extended. It fills

[10] This is just a warm-up case. We will provide a more careful characterization of three-dimensional objects in §5.

[11] We are making a few simplifying assumptions in the rest of the paper, and it is better to make them explicit right from the start. We will be mostly using a *separatist* framework -the terminology is borrowed from Gilmore, Costa and Calosi (2016) -according to which there are two disjoint and independent manifolds, namely a three-dimensional spatial manifold and a one-dimensional temporal manifold. Separatism contrasts with *unitism*, according to which there is just one fundamental four-dimensional manifold, space-time, and spatial regions and instants of time -if there are any- are just overlapping spacetime regions of different sorts. This is analogous to what Skow (2015) calls a "3+1"-view and a "4D"-view. This is mostly for the simplicity of exposition. The arguments just need a little tweak to go through in a fully unitist, four-dimensional spatiotemporal setting. As a matter of fact, we will advert the reader when a fully blown untist picture is required for the arguments to go through. Also, we work with a characterization of endurantism according to which the relation between persisting objects and time is (some form of) location. While this is widely agreed upon, it is by no means uncontroversial. Fine (2006) and Costa (2017) argue at length to that objects are not strictly speaking *located* in time. Here we should simply note that while this last claim sounds promising in a separatist-setting, it is unclear whether it can still hold up in a unitist, spatio-temporal one. One could then simply re-phrase the arguments in the main text against a fully-fledged unitist four-dimensional framework.

the interval *T* by being multi-located at each instant of *T*. Now, according to the previous definition, the persisting object is also exactly located at *T*, for it fills and is contained in it. This result is unfortunate. It either requires the object to be temporally extended – and thus contradictory – (Barker and Dowe 2003, 2005) or to sever the connection between the extension of the object and that of its location (Eagle 2010, 56). If one were to believe that extension is one property that an object and its exact location -along a given dimension- share, this would give us all the more reason to reject the idea that the three-dimensional object is exactly located at *T*.

This is the main reason why friends of multi-location do not want their multi-located objects to be forcibly also located at the union of their exact locations (Gilmore 2007). As a matter of fact, Calosi and Costa (2015) argue at length that multi-location theorists should respond to Barker and Dowe's (2003) challenge by denying exactly that possibility. Or, as they put it, multi-location theorists should deny *Additivity of Location*.[12]

Eagle then settles for another definition of exact location that does not face this problem (Eagle, 2010: 55):

[12] Calosi and Costa (2015) is particularly interesting in the present context. For their argument crucially depends on a principle they call *Region Dissection*, that is roughly the following: if x is exactly located at R_1, y is exactly located at R_2, and R_2 is a proper subregion of R_1, then, if x and y are mereologically related, y is a proper part of x. This makes what we shall label "nested multi-location" impossible. This is important insofar as Eagle's definition of exact location makes nested multi-location impossible as well. We shall return to this in due course.

> **Exact location 2**. An exact location of *O* is any region *R* that both contains *O* and is filled by *O*, as long as no proper subregion of *R* contains and is filled by *O*.

The interval is not an exact location of the persisting object anymore, for some subregions of the interval, namely the instants, are exact locations of that object, insofar as the object fills and is contained in each instant.

Unlike Parsons's definition of exact location, Eagle's definition does not imply *Functionality*, and therefore allows for multi-location. Nothing prevents something from being contained and also fill more than one region of a dimension. For example, in Fig. 2, *Circle* is exactly located at both R_1 and R_2. Indeed, it is contained in both, for each part of *Circle* occupies a subregion of both R_1 and R_2, and it also fills both R_1 and R_2, for each subregion of both is occupied by *Circle*. Moreover, no proper subregion of R_1 and R_2 is a region which contains *Circle*. Hence, *Circle* is exactly located at both R_1 and R_2.

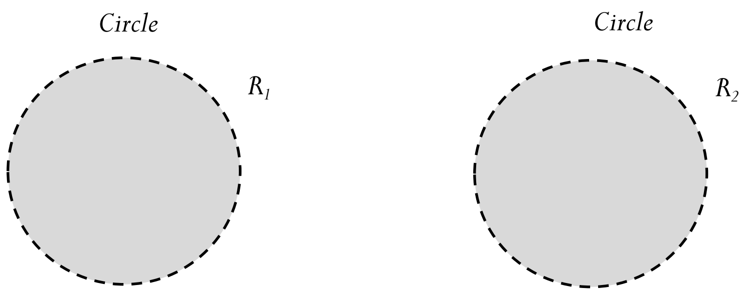

Fig. 2

This is a good result. And yet, we contend, Eagle's definition allows for multi-location only in the letter.

In what follows we shall explain how Eagle's definition does not allow entities to be multi-located in the way in which universals and persisting three-dimensional objects are. Since these cases are the main motivations to look at multi-location with interest -as we pointed out in §1- Eagle's definition, while allowing for multi-location in the letter, can be thought to betray it in the spirit. And things get worse. We will argue that Eagle's definition is unsatisfactory when it comes to the location of both *mereologically complex objects*, and *mereologically simple* but *extended* objects. As a matter of fact, it renders the latter impossible. Or so we contend. All this seems to seal the fate of Eagle's definition.

4 The Case of Immanent Universals

Let us begin with immanent universals. Under an immanent conception of universals, universals are exactly located[13] whenever and wherever they are

[13] Location is not the only relation that can be used to characterize the relation between immanent universals and things that instantiate them. Two other non-locative relations that can do the job are *dependence* and *grounding*. We need not to take side here. Perhaps immanent universals are indeed best characterized using dependence rather than location. As we will point out in due course, we don't want to rely too much on the case from universals. We are discussing this case mostly because it was one of the motivating examples in the literature on multi-location. Alternatively, we might want to make sense of the spatiotemporal profile of universals along the following lines. Immanent universals are somewhere and somewhen not in the sense that they

exemplified.[14] Whatever the final theory of location for immanent universals might be, the following principle seems to be an integral part of it:

> **Location of universals**. If something that exemplifies universal *U* is exactly located at region *R*, then *U* is exactly located at *R*.

Now consider a chair which is red all over. Suppose that the chair is exactly located at region *R*. Redness is therefore exactly located at *R* too. The chair has parts, i.e. its legs and its seat, which are also red. These red parts are exactly located at proper subregions of *R*. Therefore, redness is also exactly located at such proper subregions of *R*. Redness will therefore be multi-located at nested regions of space. Call this "nested multi-location".

Exact Location 2 makes nested multi-location impossible. For example, universal redness could not be exactly located at the region of the red chair above,[15] because there is a proper subregion of that region that contains and is

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are located at some regions of spacetime, but only in the sense that they are exemplified by something which, in turn, is located at regions of spacetime (Costa 2017).

[14] Here is a relevant quote: "Suppose we begin by helping ourselves to a respectable posit of speculative metaphysics – immanent universals. Immanent universals, by contrast with Platonic universals, are as fully present in space and time as their bearers. Moreover, they are capable of being *fully present in many places at the same time*; if two spheres are red, then the single immanent universal redness is in each of the spheres (O'Leary Hawthorne and Cover, 1998: 205, italics added).

[15] Clearly, with the locution "the region of *x*", we simply mean the exact location of *x*.

filled by that universal, e.g. the region of one of the chair's legs. For a friend of immanent universals, such cases of nested multi-location are ubiquitous. This threatens to undercut one of the two very motivations for looking with interest at the possibility of multi-location.

There are several replies to be made on behalf of Eagle and the multilocation theorist.

First,[16] one can contend that nested multi-location seems to count the redness of the parts twice over: once as it contributes to the redness of the part, and then again as it contributes to the redness of the whole. In the light of this, the multilocation theorist could (and perhaps should) endorse one of the following, in the case at hand: (i) the chair is red, and the parts are only *derivatively* red, or, conversely, (ii) the parts of the chair are red, and the chair is only *derivatively* red. This strategy crucially depends on how "derivatively" works. As far as we can see, there are two options here. According to the first option "derivatively" works in such a way that the following principle (iii) is true, namely, (iii): If x is *derivatively red*, then it is *red*. Now, according to a very minimal reading of realism about universals, if something is red, it instantiates redness. It will follow from (iii) that both the chair and its parts instantiate redness, and our argument still applies. According to the second option, "derivatively" works in such a way that (iii) is not true, in its full generality. Yet, this is still not enough to get out of the argument. For one case will be enough. Hence, what we should endorse is (iv), namely: (iv): If x is only derivatively red, then x is *not* red. And, in fact, in

[16] We owe this suggestion to an anonymous referee for this journal. The following discussion is indebted to his or her remarks.

endorsing (iv), one should conclude that the chair is not colored at all, insofar as the exemplification of a determinable implies the exemplification of at least one determinate under that determinable. The same line of reasoning would also apply to other features that the chair has only derivatively, such as its weight, shape, or size. While we concede that (iv) would solve the problem and might be regarded as a fruitful choice for those who wish to avoid counting redness twice, we expect many to prefer to stick to the idea that (if not transparent!) chairs are colored and possess a weight, a shape, and a size.

Second, Eagle might argue that a universal *U* is *not* exactly located at the spacetime region *R* where the entity *O* that exemplifies *U* is located. Rather, he might insist, *U* is *exactly located* at *O*.[17] As a matter of fact, he might even go further and claim that the locative relation between *O* and *R* on the one hand, and *U* and *O* on the other are not the same locative relation! This reply sounds promising to us. Yet, it should be admitted that it is now unclear whether immanent universals provide any reason to be interested in multi-location in the first place.[18] Let us be a little more precise. According to the suggestion we are exploring there are two *distinct* exact location relations, say EXL_1 and EXL_2. EXL_1 takes as *relata* a material object and a spatial region -in this order- whereas EXL_2 takes as *relata* a universal and a material object -in this order. There is multi-location$_1$, and there is multi-location$_2$. Multi-location$_1$ is basically what we have been calling multi-location. Multi-location$_2$ is

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[17] Note that this reply is different from the ones we sketched in footnote 12. The thought here is that universals still enter into some sort of *locative* relation, albeit with no region.

[18] Thanks to Antony Eagle here.

just a universal being exactly located at more than one object. The point we are making is that the location of universals is hardly any motivation to explore multi-location$_1$, which was our original interest. Note that Eagle might consistently claim that nested mutli-location$_1$ is impossible, whereas nested multi-location$_2$ is not only possible but ubiquitous. Go back to our example of a chair that is red all over. Redness is exactly located at the chair, and at one of its legs. This is a case of nested multi-location$_2$.

More generally, Eagle might want to restrict his theory of location to material objects, so as to undermine our argument from the location of immanent universals. This is fair enough. As a matter of fact, we don't want to put too much weight on our argument from universals. As we pointed out in footnote 12, it might turn out that *location* is not the right sort of relation to characterize the metaphysics of immanent universals. That being said, it seems important to us to discuss it, at least insofar as universals have been usually invoked as paradigmatic examples of multi-located entities.

5 The Case of Material Objects

In the previous section we saw that Eagle's definition renders nested multi-location impossible. Nested multi-location is ubiquitous when it comes to immanent universals. One might note that cases of nested multi-location for objects have been discussed as well, most notably in Kleinschmidt (2011) and Effingham (Forthcoming). As a matter of fact, Eagle (2016b) acknowledges this, and argues that rejecting cases of nested multi-location for objects is attractive for multi-location theorists. Calosi and Costa (2015) argue for the same conclusion on different grounds. So, it is at least controversial to invoke the possibility of nested multi-location as an argument against a definition of exact location that permits multi-location.[19] We don't want to press the point here. This is because we are about to argue that even in the case of objects, **Exact Location 2** faces serious problems that are *independent* from the possibility of nested multi-location.

Let us start from three-dimensionalism. We start from there because, in the case of objects, three-dimensionalism is usually recognized as the main motivation to take multi-location seriously, insofar as three-dimensionalism entails multi-location. Roughly, according to the three-dimensional view, persisting objects are three-dimensional entities, that are extended in space but not through time. In order to persist through time without being temporally extended, such objects need to be exactly located at all and only the unextended instants of time, or instantaneous regions of spacetime, that make up the interval of their persistence. Hence, persisting three-dimensional objects are temporally multi-located entities (Donnelly, 2010, 2011; Eagle, 2010; Gilmore 2006, 2007; Hawthorne, 2008; Sattig 2006; *pace* Fine, 2006; Parsons, 2007, and Costa 2017). On that respect too, Eagle's proposal is problematic. For persisting objects typically change their parts through time. And Eagle's proposal makes such changes impossible. Indeed, Eagle's definition of exact location requires a multi-located entity to have all its parts contained within each of its exact locations. So, a persisting object should have all its parts contained within each of the instants of its persistence. If at *t,* Tibbles the cat does not have its fur anymore,

[19] See footnote 11.

Tibbles is not contained in, and therefore is not exactly located at *t*. More generally, under Eagle's definition, any mereological change would result in the persisting object not being contained, and thus not exactly located at some instants of its existence. Let us focus on two particular cases, for dramatic effect.[20]

Tibbles 1. Suppose Tibbles comes into existence at instant t_1 with all the parts it will ever have. Suppose that at every instant Tibbles loses one of those parts.[21] At instant t_n Tibbles goes out of existence. The only instant in which Tibbles is contained, and thus at which it is exactly located, is instant t_1. This is intuitively wrong. Not only this is intuitively wrong. A stronger argument can be built on this case. We need just to briefly introduce a few more notions in Gilmore (2006). For the sake of simplicity, we stick to the temporal case, rather than the

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[20] It is worth noting that Eagle is upfront in Eagle (2016a) that he is really interested in the persistence of simples. He writes: "the present conception of endurance is perhaps best suited to capture the persistence of simple objects that cannot gain or lose parts, like fundamental particles, rather than complex objects" (Eagle, 2016a: 513). In a footnote to that passage Eagle mentions Fine's idea that complexes might be variably embodied by collections of simples-at-times rather than time-relativised mereological fusions. We note two things: first, this amounts to abandoning the idea that apparent change of parts is to be understood in standard mereological terms. And this is a fairly radical revision to orthodox endurantism. Second, we are about to argue that Eagle's theory of location cannot accommodate *extended simples*. Putting all this together---as we note later on---this amounts to the claim that Eagle's theory of location *only applies to point-sized simple material objects*. Thanks to an anonymous referee here.

[21] We are well aware that this is physically unrealistic. Also, it will entail that Tibbles has uncountable many parts. Bear with us.

spatio-temporal one.[22] Let the path of an object be the union of its exact locations. Something persists iff its path is not instantaneous. This is supposed to capture the requirement in Lewis (1986) to the point that persisting means to exist at more than one instant. A three-dimensional object is a persisting object that is exactly located at each instant of its path, whereas a four-dimensional object is a persisting object that is uniquely exactly located at its path. Now, we already argued that, in the case at hand, Tibbles is exactly located just at t_1. Thus, Tibbles' path *is* t_1. But this means that Tibbles is not a persisting object after all. That is surely bad news for the three-dimensionalist.

Tibbles 2. Suppose that Tibbles comes into existence at t_1. At every instant t_{j+1}, Tibbles loses one of the parts it had at t_j, but it acquires a new one. At t_n Tibbles goes out of existence. According to **Exact Location 2**, Tibbles is only contained in the entire interval $T = (t_1\text{-}t_n)$. Note that the interval T is also Tibbles's path. It follows that Tibbles is a persisting object that is uniquely exactly located at its path. Hence, Tibbles is a four-dimensional object.

Thus, **Exact Location 2**, in attempting to make room for multi-location and three-dimensionalism, makes three-dimensional mereologically changing objects impossible.

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[22] As we pointed out already in footnote 10 the argument would need a little tweak in a unitist, spatio-temporal setting, but it would still go through. The reader can check for herself.

As we have said, the two cases only illustrate in the most dramatic manner the shortcomings of Eagle's definition of exact location. The resulting location theory cannot handle cases of mereological change. Arguably, a three-dimensionalist would not like to commit her view to the impossibility of mereological change and would thereby reject Eagle's definition.

Even in this case, there is a possible reply to be given on behalf of Eagle. The problematic cases we explored are cases of mereological *change*. One can insist that, when *mereological change* is involved, a three-dimensionalist should *relativize at least the mereological notions*. That is, she should take parthood to be a three-place relation. We should notice that Eagle himself uses a two-place notion of parthood, perhaps because he brackets questions of mereological change in Eagle (2010). Be that as it may, the suggestion is surely interesting and deserves to be explored. So, let's take parthood to be three-place. The question becomes: what goes in the third slot? The most natural candidate would be an instant of time: the leg is part of the chair at time t, the fur is part of Tibbles at time t.

Now, nothing in the definition of **Exact Location 2** prevents objects to be multi-located at the same instant. In those cases, our arguments will go through. And, as a matter of fact, these are cases a three-dimensionalist might want to consider. For they simply follow from the possibility of time-travel. If time travel is possible, and thus a three-dimensional object can be multi-located at different regions of space at the same instant, Eagle's definition would still be in trouble if we allow the object to change its mereological structure at those different regions. This might suggest that the third slot should not be filled by an instant of time, but rather by a region of space, or spacetime: the leg is part of the chair at region *r*, the fur is part of Tibbles at region *r*. But which region? The most natural candidate is the exact location of the object in question. But the problem with this suggestion is that we seem to be moving in a circle: Exact location is defined in terms of containment, and containment is defined in terms of parthood. Parthood, in turn, has to be relativized to exact locations. Hence, it seems that we need exact location in order to properly characterize containment, but we need containment in order to define exact location.

One might want to resort to one last attempt to save **Exact Location 2**. First, one should claim that time-travel is *the only relevant* scenario in which there is multi-location at an instant. This is already quite a substantive claim. But never mind. Then, one might continue, we should also consider another candidate to go in the third slot of our mereological claims, namely *personal time*. This response builds upon the classic distinction in Lewis (1976) between *personal* and *external time* in time-travel cases. Fair enough. We don't think this reply would go too far. Without entering into much detail, it would simply not work for mereologically complex objects in relativistic spacetimes.[23] In a nutshell the problem is that *personal time is reasonably taken to be proper-time* in relativistic spacetimes. And, as Gibson and Pooley (2016: 172) note: "[F]or realistic persisting objects, *no sense can be made of such an object's proper time*". We are aware that these considerations are likely not to settle the dispute once and for all. But what we want to claim is

[23] This is where a fully-fledged unitist framework enters crucially into the picture. It is widely agreed that relativistic physics favors unitism. For an introductory review of different arguments see Gilmore, Costa and Calosi (2016).

that it is at best unclear how to amend the definition of **Exact Location 2** in order to account for the cases we have just discussed. Fortunately for us, we *don't need* to settle things once and for all when it comes to cases of mereological change involved in time-travel scenarios. This is because we think there are serious problems that are independent of mereological change -and independent of time-travel for what matters. If we are right, none of the considerations above would salvage Eagle's proposals from such problems.

The discussion so far seems to suggest that the only problem -if any- for **Exact Location 2** is mereological change, when applied to material objects. Thus, one might be tempted to conclude that, if we restrict the definition to mereologically *constant* objects, the definition would work just fine. This is not quite right. We now turn to set forth an argument -**Circle 1** below - to the point that this is not the case. Mereological *complexity* is enough to spell trouble for the definition in question, even if no mereological change is involved.[24]

Circle 1. Let us consider *Circle* again. *Circle* is a *circular self-connected* entity, multi-located at regions R_1 and R_2 -as depicted in Fig.3 below.

[24] Thanks to Antony Eagle here.

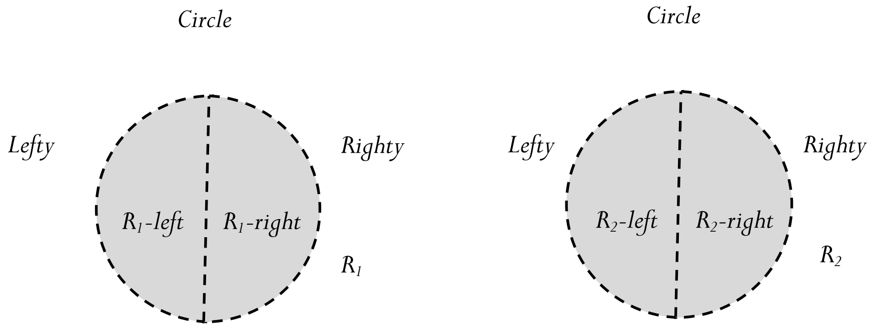

Fig.3

At both R_1 and R_2 *Circle* is composed by two parts, *Lefty* and *Righty*. *Lefty* itself is multi-located, namely at R_1-*Left* and R_2-*Left*. The same goes for *Righty*. Now consider region R_3, which is the union of R_1-*Left* and R_2-*Right*. *Circle* is contained in R_3, fills R_3 and there are no proper subregions of R_3 that contain and are filled by *Circle*. Hence *Circle* is exactly located at R_3. This is, once again, intuitively wrong.

The problem is, in general, an *overgeneration of exact locations*. Consider what we would normally describe as *Circle*'s being multi-located at *n* regions. Suppose each of the *n*-regions R_i is the union of R_i-*Left* and R_i-*Right*. It would follow that any region that is the union of R_i-*Left* and R_j-*Right*, for *any i* and *j*, would count as an exact location of *Circle*. (In some cases, this would be particularly problematic. Suppose *you* get to be multi-located---perhaps as a result of time-travel---say, in London and Paris. Now take the union of the left region in London and the right region in Paris. *You* get to be exactly located there too.)

Note that no mereological change is involved in the **Circle 1** argument. *Circle* has the same mereological structure at R_1 and R_2.[25]

One might insist that three-dimensionalism is indeed the main motivation to endorse multi-location in the case of objects. And then go on to claim that three-dimensionalists should endorse a three-place notion of parthood even in the absence of mereological change. Yet, we framed the **Circle 1** argument in terms of a two-place notion of parthood. However, our previous replies apply in the present context as well. If one has a three-place notion of parthood in which the third slot is occupied by an instant of time, the **Circle 1** argument would still go through. If one has a three-place notion of parthood in which the third slot is occupied by a region a threat of circularity is still lurking. Thus, we conclude the **Circle 1** argument stands.

The **Circle 1** argument seems to suggest that the problem of **Exact Location 2** is *mereological complexity* more in general. Thus, the only way to resist the arguments seems to *restrict* **Exact Location 2** *to mereological simples* and insist that mereological simples cannot change mereological structure, i.e. they cannot become mereologically complex -to take care of **Tibbles 1** and **Tibbles 2**.

Once again, this would not be quite right. To conclude we set forth a final argument -**Circle 2** below- to the point that **Exact Location 2** cannot handle particular cases of mereologically *simple* objects, that is *extended simples*. As a

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[25] We should also note that there no *Additivity* principle for location is needed to run the argument.

matter of fact, we think the argument is particularly illuminating. It starts out by claiming that **Exact Location 2** delivers the wrong results about the exact location of extended simples. And it ends by denying their very possibility! But we are getting ahead of ourselves. In what follows we follow the widespread agreement in the metaphysics literature,[26] and we take an extended simple to be

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[26] We want to point out that, as duly noted by a reviewer of this journal, we are not using the term "extended simple" in the way in which McDaniel used it in his (2007) or Eagle uses it in his (2019), but rather in the sense defined in the main text, which is also the sense to be found, for example, in Scala (2002), Simons (2014), Pickup (2016) and Gilmore (2018). This sense is closer to what McDaniel (2007) calls a "spanner". Eagle (2019) distinguishes between *f-extended* simples and *l-extended* simples. The former notion is defined in terms of *containment* alone, whereas the latter notion is defined in terms of what we called *entire location* in footnote 4. Eagle (2019: 170) claims that *l-extended simples* can be used to *approximate*---Eagle's own words---spanners. It is worth exploring whether the argument could be strengthened, to the point that *any* theory of location that defines exact location in terms of weak location cannot handle spanners. In general, we think this is not the case. Parsons defines exact location in terms of weak location in his (2007). Yet, it can be shown that every persisting entity counts as a spanner in his system. Parsons's system, as we pointed out already, entails *Functionality*. So, the question becomes whether *any* theory of location that defines exact location in terms of weak location *and* allows for multi-location makes spanners impossible. The reviewer suggests that this might be the case for, arguably, any theory of location that allows for multilocation and defines exact location in terms of weak location will entail the following principle *P*: if x is exactly located at R, then x is not *contained* in any proper subregion of R---the reader can check that, in effect, *P* does not follow from Parsons's definition of exact location. Once again, we think that this is not the case. A counterexample is **Exact Location 1** in the text. This is because according to **Exact Location 1**, nothing prevents an object x to be exactly multi-located at two distinct regions R_1 and R_2, and at their union. Thus, an object could be exactly located at a region and be contained in one of its proper subregions. To be fair, **Exact Location 1** makes spanners impossible for the very

a mereologically simple entity that is not point-like. If the standard real topology of space is assumed, this definition boils down to the following one: an extended simple is a mereological atom whose exact location is mereologically complex. [27] Now to the argument.

Circle 2. Consider *Circle* again. This time though, *Circle* is an extended simple. Call *R-Circle* the relevant spatial region that shares the same geometrical properties with *Circle*.[28] *R-Circle* should be the exact location of *Circle*. Unfortunately, **Exact Location 2** does not deliver that result. To appreciate why, consider an arbitrary proper subregion of *R-Circle*, e.g. R_1 in Fig 4 below.

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same reason **Exact Location 2** does---the argument being exactly the one in the main text. So, the conjecture, independently of the fate of *P*, still stands: any theory of location that defines exact location in terms of weak location *and* allows for multi-location makes spanners impossible. Eagle (2019: 170) contains an interesting argument in this respect. Yet, the argument falls short of securing the aforementioned conjecture, for it crucially relies on the definition of spanners in terms of entire location. As a matter of fact, Eagle claims that if spanners are defined in terms of our notion of exact location---Eagle's *perfect location*---the argument does not go through. Thanks to an anonymous referee here.

[27] As a matter of fact, we think that this is but one (overtly simplistic) characterization of extended simples. There are other characterizations that are not extensionally equivalent. See (Goodsell et al. forthcoming). That being said, even those different characterizations will spell out trouble for **Exact Location 2**. Thus, we will just stick to the orthodox definition here. We should also note that this definition works only within the orthodox understanding of space, according to which space is "constructed out" of simple, unextended spatial points endowed with the so-called real topology.

[28] Clearly, "having a particular mereological structure" is not among the geometrical properties that *Circle* and *R-Circle* share.

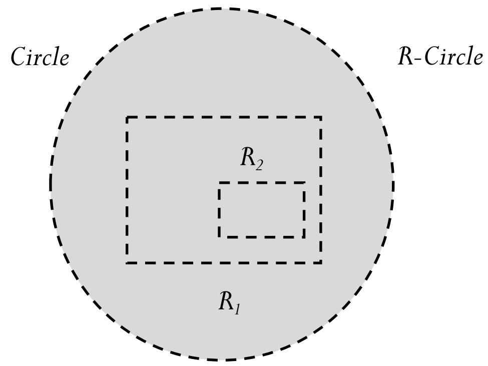

Fig. 4

Recall that according to **Exact Location 2** something is exactly located at a region if it is contained and fills that region, *provided there are no proper subregions of that region that it fills and is contained in.* Is *Circle* contained in R-*Circle*? Yes, it is. Does *Circle* fill R-*Circle*? Yes, it does. Are there any proper subregions of R-*Circle* that *Circle* fills and is contained in? Unfortunately, yes. There are many of those -as a matter of fact we will argue in a minute there are uncountably many. Consider R_1. Every part of *Circle* occupies R_1 -for *Circle* has only one part, itself, and that part clearly occupies R_1. Thus, *Circle* is contained in R_1. Also, *Circle* clearly fills R_1. This is enough to show that *Circle*, according to **Exact Location 2** is not exactly located at R-*Circle*. Is it exactly located at R_1? Not really. For the previous argument still applies. Consider any proper subregion of R_1, e.g. R_2 in Fig 4. *Circle* both fills and is contained in R_2. Thus, it cannot be exactly located at R_1 either. The attentive reader already guessed where this is going. The argument above applies to all proper subregions of R-*Circle* that have proper-subregions. It follows that *Circle* cannot be exactly located at any mereologically complex subregion of R-*Circle*.

The only candidate exact locations of *Circle* are subregions of *R-Circle* that do not have proper subregions, i.e. spatial points. Each point in *R-Circle* would count, as a matter of fact. Thus, it seems that *Circle* has uncountably many exact locations that are point-like. Naturally what goes for *Circle* goes for any extended simple whatsoever. This is surely wrong.

There is more. The right conclusion to draw is not that extended simples have uncountably many point-like exact locations -even when they *seem* to have just one exact location we might add. The right conclusion to draw is that extended simples *are not possible* given **Exact Location 2**. To see why, recall that extended simples are defined as mereological atoms that have a mereologically complex exact location. That is, they are mereological atoms whose exact location *is not a point*. But our **Circle 2** argument shows that *points are the only candidate* exact locations for extended simples. Extended simples turn out to be contradictory entities,[29] i.e spatial entities that both have and do not have point-like exact locations. Under the assumption that contradictory entities are not possible, **Exact Location 2** yields that *extended simples are not possible*.[30]

[29] This conclusion should be intended as restricted to the notion of extended simple as it is defined in the paper. McDaniel (2007) distinguishes two notions of extended simples, namely *multilocaters* and *spanners*. *Multilocaters* are extended simples insofar as they are simple entities that *fill* an extended region *R* of space by being multilocated throughout *R*. Given Eagle's theory of location, multilocaters *are* clearly *not impossible*. Only spanners are. As we pointed out in footnote 25 it is an interesting conjecture whether any theory of location that defines exact location in terms of weak location and allows for multilocation renders spanners impossible. Thanks to an anonymous referee here.

[30] It should be clear that taking parthood as three-place would be of no help to undermine the **Circle 2** argument.

This, we take, is an enormous cost. As a matter of fact, it might very well be that the fundamental constituents of our world turn out to be extended simples.[31]

6 Conclusion

This concludes our assessment of Eagle's proposal. To sum up: Eagle's proposed definition of exact location does indeed allow for multi-location. This is an important result. However, it faces important drawbacks. Where does that leave multi-location theorists? Listing all the options, they can:

(i) Accept two primitive notions of location, be committed to problematic metaphysical brute facts, or explain why these facts are not problematic after all;

[31] See e.g. Simons (2004) and Braddon Mitchell and Miller (2006). At this point, one might try to resist the argument simply by claiming that Eagle does not accept the definition of extended simples given above. This reply, we contend, is less than satisfactory. First of all, the notion is clearly definable in Eagle's terms. The question is whether any such thing is possible. Eagle is committed to the impossibility of such things. And yet, one has reasons to take extended simples (as we defined them) seriously. Electrons might be taken to be good examples. They are extended, and the best physical theory that describes their behavior, quantum mechanics, is usually taken to entail that, at least in *some* cases, they have exact locations. Does this undermine our previous argument against *Exactness*, given that we cited Quantum Mechanics as providing counterexamples to it? Not really. Orthodox Quantum Mechanics predicts that *sometimes* quantum systems do not have exact locations. That does not mean that they *never* have one. For example, after a measurement of position is made, quantum systems do have an exact location. If the quantum system in question is an electron, it *will qualify as an extended simple* given the definition we used in the paper (Gilmore 2018). This seems enough to lay claim that extended simples as we defined them are indeed possible, contra Eagle's theory of location.

(ii) Accept exact location as a primitive, define weak location in terms of it, and dismiss counterexamples to *Exactness*;[32]

(iii) Accept weak location as a primitive, use **Exact Location 2** as a definition of exact location, *and restrict it to mereologically constant, simple,* and *unextended* material objects---that is, just to point-like material objects.

(iv) Accept weak location as a primitive and put forward new, better definitions of exact location.

We are not claiming this is an impossible task. But, in the light of the above, it seems safe to say that the road out of the multilocation trilemma is still a long and winding road.

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[32] Or even, they can try to define weak location in terms of exact location in such a way that *Exactness* does not follow. We are not aware of any such attempt in the literature.

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