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Temporal Parts and Time Travel

ABSTRACT: This paper argues that, in light of certain scenarios involving time travel, Sider’s definition of ‘instantaneous temporal part’ cannot be accepted in conjunction with a semantic thesis that perdurantists often assume. I examine a rejoinder from Sider, as well as Thomson’s alternative definition of ‘instantaneous temporal part’, and show how neither helps. Given this, we should give up on the perdurantist semantic thesis. I end by recommending that, once we no longer accept such semantics, we should accept a new set of definitions, which are superior in certain respects to Sider’s original set.

1. The Problems

1.1 Introduction

The literature dealing with time travel and the metaphysics of persistence usually focuses on problems for endurantism [Effingham and Robson 2007; Effingham 2010; Miller 2006; Sider 2001: 101-9, 2005], with only little exception made for the difficulties perdurantism encounters [Gilmore 2007]. This paper adds a voice to that latter minority, demonstrating that given the possibility of time travel perdurantists cannot define what a temporal part is without giving up on a semantic thesis that perdurantists commonly endorse.

This section explains how Sider’s definition of temporal part (when combined with the aforesaid semantic thesis) is inadequate in certain time travel scenarios. §2 demonstrates that Sider’s response to the problem is unsatisfactory. §3 demonstrates that using an extant alternative definition won’t help either. §4 lays out the reasons for thinking that we have to have a definition

of temporal part. So, as there is no suitable redefinition available, the only option is to deny the semantic thesis. §5 argues that there are few costs accrued by this denial, and that we should further introduce new definitions which prove to be superior to Sider’s original definitions.

1.2 The Two Problems

The standard definition of ‘instantaneous temporal part’ is Sider’s:¹

- (1) x is an instantaneous temporal part of y at time t =_{df} (i) x is a part of y ; (ii) x exists at, but only at, time t ; (iii) x overlaps every part of y that exists at t . [Sider 2001: 60]

Sider introduces (1) with the explicit intention of meeting the demands of those critics who claim that the notion of ‘instantaneous temporal part’ is unintelligible [Sider 2001: esp. 53- 62].

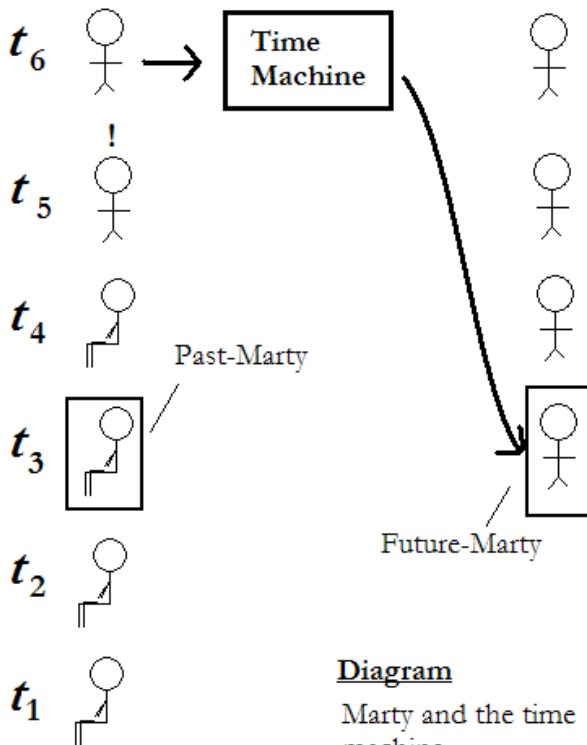


Diagram
Marty and the time machine

¹ Sider has an alternative definition, using temporally relativised mereological relations rather than the atemporal relations given in (1). This is Sider’s irenic effort to placate endurantists who don’t accept atemporal mereological notions. As the definitions are equivalent for the perdurantist, whichever version you use won’t make any difference. So, in the name of simplicity, I stick solely to the atemporal version.

He then defines perdurantism as the thesis that every material object has an instantaneous temporal part at every instant at which it exists [Sider 2001: 59].

Many perdurantists [Armstrong 1983: 79; Chandler 1970; Hawley 2001: 13; Le Poidevin 1991; Lewis 1986: 202-4] also endorse the following semantic thesis:

(2) y is F at time t iff (i) x is an instantaneous temporal part of y at time t ; (ii) x is F .

Admittedly, there have been many modifications made to (2) in light of evidence that it cannot be a wholly general principle. For instance, some perdurantists modify (2) so that it does not apply to sortal predicates [Parsons 2005]. It also looks like the perdurantist will have to say something different about abstracted predicates (e.g. the predicate featuring in ‘Marty is such that the speed of light is $299,792,458 \text{ ms}^{-1}$ ’) [Sattig 2002]. The perdurantist may also have to say tricky things in order to extend (2) to a more general analysis of predicates which linger, and are had, not at any instant, but over a period of time [Balashov 2007]. So, as far as the perdurantists are concerned, (2) is a work in progress. But whatever the details of the changes that might be made, the standard consensus is that something like (2) will form the core of a perdurantist semantics. At the very least, no matter what modifications are made in light of concerns regarding sortal predicates, abstracted predicates etc. (2) is meant to be true of the ‘normal’ predicates (i.e. those had instantaneously and which do not linger; that are not sortal predicates or abstracted predicates etc.), such as ‘__ is tall’; ‘__ is short’; ‘__ is sitting’; ‘__ is standing’; ‘__ is heavy’; ‘__ is skinny’ and so on. This paper argues that even in such ‘normal’ cases, (2) is false. So it isn’t that (2) just needs tweaking, or modifying a bit here and there, but that no semantic thesis akin to (2) is true in the first place.

The following scenario makes clear the problem. Imagine that Marty is sitting at t_1 and t_2 , contemplating the time machine he has just built. At t_3 a man who looks just like Marty materialises out of thin air on the far side of the room. At t_4 Marty sits and wonders who this person is (clearly Marty isn’t that bright!). At t_5 he shoots up with the realisation that the person looking at him is himself from the future. At t_6 Marty steps into his time machine, which teleports him to t_3 . Upon arriving in the past, Marty stands looking at his bemused self (at t_4) come to realise the situation (at t_5) and step into the time machine (at t_6). The instants in this story are depicted in the diagram. It also depicts the ten instantaneous person shaped objects which are parts of Marty at those times.

At t_3 , Marty is both sitting and standing.² So, given (2), Marty must have two instantaneous temporal parts at t_3 , one that sits and one that stands. Of the ten person shaped objects in the diagram, two are obvious candidates for being such temporal parts – the ones marked Past-Marty and Future-Marty. Past-Marty is an instantaneous part of Marty that is sitting. Were it to qualify as an instantaneous temporal part of Marty at t_3 then, given (2), Marty would be sitting at t_3 . Similarly, were Future-Marty an instantaneous temporal part of Marty at t_3 then Marty would be standing at t_3 . There are two problems with this.

Problem one: The first problem is that this natural identification of Marty’s temporal parts does not follow given (1). To demonstrate: Past-Marty is a part of Marty that exists only at t_3 , so fulfils the first two conjuncts of the right hand side of (1). But Past-Marty has no parts in common with Future-Marty. For example, none of the instantaneous temporal parts of the atoms that compose Future-Marty’s hands are part of Past-Marty. Therefore, as Future-Marty is a part of Marty that exists at t_3 , Past-Marty *doesn’t* overlap every part of Marty that exists at t_3 . Consequently, Past-Marty does not satisfy the third conjunct and so is not an instantaneous temporal part of Marty. Parallel reasoning applies to Future-Marty. The problem with this is that the *only* parts of Marty that are sitting and standing, and that exist only at t_3 , are Past- and Future-Marty respectively. So

² There is no contradiction in that for it is not as if he is standing and *not* standing. Whereas sitting *usually* implies that one does not stand, this is not so when a time machine is involved.

if *they* are not instantaneous temporal parts of Marty at t_3 then, given (2), Marty *doesn't* sit and stand at t_3 as should be the case.

Problem Two: The fusion of Past- and Future-Marty, call it Freak-Marty, *is* an instantaneous temporal part of Marty at t_3 . To demonstrate: everything that is part of Marty at t_3 is either a part of Past- or Future-Marty (or an object composed out of parts from both Past- and Future-Marty). As Freak-Marty is composed of Past- and Future-Marty then every part of them is a part of Freak-Marty (and every object composed out of parts of them is, by the theorem of classical mereology given below, also a part of Freak-Marty). So every part of Marty at t_3 is a part of Freak-Marty. Hence Freak-Marty fulfils the third conjunct of the definition. Freak-Marty is composed of two objects, Past-Marty and Future-Marty, that exist at (and only at) t_3 , so clearly Freak-Marty exists at (and only at) t_3 , fulfilling the second conjunct. Finally, it is a theorem of classical mereology that if x and y are parts of a whole then the fusion of x and y is a part of that whole [Simons 1987: 39, esp. SCT 36] so, as Past- and Future-Marty are parts of Marty, Freak-Marty must be a part also. Hence, Freak-Marty fulfils the first conjunct. The demands of all three conjuncts are met, so Freak-Marty is an instantaneous temporal part of Marty. The problem with this is that Freak-Marty well deserves its name. It has four arms, is neither sitting nor standing, and does not think (it has thinking *parts*, but no more thinks than the fusion of myself and the Eiffel Tower). So were Freak-Marty an instantaneous temporal part of Marty at t_3 then (given (2)) Marty would have four arms at t_3 , neither sit nor stand at t_3 and wouldn't even be conscious at t_3 . All of this is intuitively false, for time travellers who go back to a time that they already exist at do not gain extra arms, neither sit nor stand, nor lose the ability to think. To demonstrate that this is intuitive, imagine a scenario where someone decides to use a time machine to travel back to the point of their birth and then live in the past until the day they die (where their death takes place before their past self uses the time machine). Given the second problem, their instantaneous temporal parts would, at every instant that they existed, be just like Freak-Marty. As none of the time traveller's temporal parts would be conscious, it would (given (1) and (2)) follow that they were *never* conscious. Simply observe the audience of any science fiction movie depicting such a scenario, and you will see that no-one grips the chair in horror or shakes their head at the folly of such time travel on the grounds that it renders the protagonist utterly insensible throughout the entirety of their existence. And I think this lack of chair gripping is enough to demonstrate that, intuitively, we do not think that Marty has the properties Freak-Marty has and that Marty is, in fact, conscious at t_3 (as well as sitting and standing at t_3 etc.). So the perdurantist who endorses (2) must ensure that Freak-Marty is not an instantaneous temporal part of Marty³ (and, indeed, ensure that Future- and Past-Marty *are* instantaneous temporal parts of Marty).

³ Freak-Marty should, however, be a temporal part of Marty (see *n5* below) for if Marty had not time travelled then Freak-Marty would have been a temporal part of Marty – albeit a non-instantaneous temporal part that existed at two different instants, that was composed of Past-Marty (existing at one instant) and Future-Marty (existing at another). So Freak-Marty would be composed of those two objects, and be a temporal part of Marty at the discontinuous interval that was composed of the two instants that Past- and Future-Marty existed at. I see no reason to change what is said in the time travel case, so Freak-Marty should still be a temporal part of Marty. So, when time travelling, Freak-Marty is a temporal part that exists for but an instant, but isn't what has been called an 'instantaneous temporal part'. That there's a temporal part that exists for an instant and yet is not an 'instantaneous temporal part' is nothing more than a terminological *faux pas*. Given (2) we are interested in the temporal parts that account for perduring wholes falling under certain predicates. In non-time travel cases such things are instantaneous, hence the labelling of them as 'instantaneous temporal parts'. But this second problem shows that not every temporal part that exists for an instant explains why perduring wholes fall under predicates like '___ is sitting' etc. hence the *faux pas*. Perhaps a new term should be coined ('interesting temporal part'; such that the predicates an object falls under at a given time depends upon its interesting temporal parts, and we then try and find a definition for 'interesting temporal part') but in keeping with the terms used in the literature on perdurantism, I retain 'instantaneous temporal part' even though it is somewhat misleading.

In light of these problems, §2.1 examines Sider's attempt to solve the problem by modifying (2). §2.2 – §4 examine various ways to revise (1) in the hope of avoiding the problems. None of these strategies work and so in §5 I consider dropping (2) entirely. I argue that this option is the best one.

2. Sider's Response

2.1 Sider's Response I: The Lexical Strategy

Sider implicitly notes both problems, agreeing that Marty should both sit and stand at t_3 . He offers this solution:

Suppose I travel back in time and stand in a room with my sitting 10-year-old self. I seem to be both sitting and standing, but how can that be? *The four-dimensionalist's answer is that there are two distinct person stages, one standing, the other sitting.* Given [(1)] the fusion of these two stages counts as my temporal part at the time in question, so let us understand 'person-stage' to refer to 'person-like' parts of temporal parts. *Ordinarily my temporal part at any time is a person stage, but not in cases of time travel.* [Sider 2001: 101; emphasis added]

As the emphasised sentences make clear, for Sider it is not because the *temporal part* is F that an object is F at any given time, but because its *person stage* is F (e.g. Marty's person stages at t_3 sit and stand, so Marty sits and stands at t_3). It's just that *usually* person stages are temporal parts (so *usually* (2) turns out to be true). So Sider modifies (2):

(3) y is F at time t iff (i) x is a person stage of y at time t ; (ii) x is F .

As Sider makes clear (in the second emphasised sentence) (3) is but a minor revision, for the only scenarios wherein there is a difference between temporal parts and person stages are those involving time travel. But this doesn't solve the problem – it just shuffles the terminology around. Whilst we no longer need to define 'instantaneous temporal part', we now need to define what a 'person stage' is (which Sider does do; I discuss his definition below in §2.2).

Indeed, as the *only* situation where 'person stage' and 'temporal part' come apart involve time travel, where it is 'person stage' and *not* 'temporal part' that does the work, we may as well give up on 'temporal part' talk altogether. Consider all of the ways that temporal parts are deployed: problems in vagueness; material coincidence; temporary intrinsics; issues with special relativity [Sider 2001: ch. 4-5]; Lewis's Postscript B argument [Lewis 1983: 76-7] etc. All of these problems would be just as solvable in terms of perduring fusions of person stages as they would be in terms of perduring fusions of temporal parts. More so even! For when we come to time travel scenarios 'temporal part' won't be good enough whereas 'person stage' will. So all of the interesting metaphysical work can be done solely in terms of 'person stage', and we shouldn't bother with temporal parts at all. The only time they need be mentioned is to define what a person stage is (i.e. a person stage is a person-like part of an instantaneous temporal part). But past that definition, we need never mention them again, so there's no need to mention them to begin with. Just define a person stage of x at t as being that person-like part of an object y , where y is an instantaneous part of x such that every part of y overlaps every part of x that exists at t . So 'instantaneous temporal part' becomes just a superfluous piece of terminology, and of no real metaphysical interest.

Thus, given Sider's modification, nothing has really been achieved. All that has happened is that where the original theory reads 'instantaneous temporal part' Sider's revised theory replaces it with 'person stage'. But whether you use the term 'person stage' or the term 'instantaneous temporal part', we still need a definition for whatever term you introduce, so our tasks are still the same. No substantial move towards a solution has been made, just a change in lexicon. So we may as well stick with the terminology already in place, and talk about 'instantaneous temporal parts' rather than 'person stages'. In other words, we must redefine (1).

2.2 Sider's Response II: The –Like Strategy

Sider's response from above is still useful though, for Sider *does* define 'person stage': 'person stages' are the person-like parts of the objects picked out by the right hand side of (1). So we could take *that* definition to be a definition of 'instantaneous temporal part':

- (4) x is an instantaneous temporal part of y at time $t =_{df}$ (i) x is a part of y ; (ii) x exists at, but only at, time t ; (iii) x is person-like.

(4) needs immediate amendment, for tables, chairs, mountains etc. all perdure and do so quite happily without any person-like parts. But 'person-like' was clearly intended to be just a placeholder, and we can alter (4) so that the relevant kind the temporal part must fall under turns out to be a different kind depending upon the kind of object it is a temporal part of:

- (5) x is an instantaneous temporal part of y at time $t =_{df}$ there is some kind K (i) K meets certain conditions X ; (ii) y is a K ; (iii) x is K -like; (iv) x is a part of y ; (v) x exists at, but only at, time t .

The first conjunct is included to make clear the problems facing (5), for – as the rest of this section explains – not just any kind can be the kind relevant to determining the temporal parts of an object. Clearly Sider thinks the relevant kind for a person would be 'person' (so its temporal parts must be 'person-like'). Presumably, his thinking is that for a table it would be 'table' (so its temporal parts must be 'table-like'); for a mountain it would be 'mountain' (so its temporal parts must be 'mountain-like') etc. So, initially, we might ensure that however we cashed out X in the first conjunct of (5), those kinds would qualify. But there are problems if they do. For instance, if 'person' was a relevant kind then, given (5), temporal parts of unborn children would turn out to be temporal parts of their mothers.

To demonstrate: assume that the kind 'person' meets the conditions of the first conjunct in (5). The mother is a person (so the second conjunct is met). What we would normally think of as the baby's instantaneous temporal parts are person-like (so those instantaneous things meet the third conjunct). The baby is a part of the mother, so – from the transitivity of parthood – those person-like instantaneous things are a part of the mother (so the fourth conjunct is met). Finally, those person-like instantaneous things only exist for an instant (so the fifth conjunct is met). Ergo, the things we normally think of as instantaneous temporal parts of the baby will, given our assumption, turn out to be instantaneous temporal parts of the mother.

But if the baby's instantaneous slices are instantaneous temporal parts of the mother then, given (2), women would have the properties of being unborn, having undeveloped anatomical structures etc. at all times at which they were pregnant. As this is obviously false, those who endorse (5) had better not think 'person' is the relevant kind i.e. think that whatever goes in place of X in the first conjunct of (5) rules out the kind 'person'.

One might object that babies aren't parts of their mothers, merely attached to them, or that the unborn aren't people. But such objections don't apply to all kinds. Consider:

Example one: Imagine a painting mosaic composed of other distinct paintings. The mosaic would have as parts both the smaller paintings and (by the transitivity of parthood) what we normally think of as their instantaneous temporal parts. As the instantaneous temporal parts of the smaller paintings would be 'painting-like', and that is presumably what will count as the relevant kind K , then (given (5)) the instantaneous temporal parts of the smaller paintings double as instantaneous temporal parts of the larger painting. So, as the instantaneous temporal parts of the smaller paintings are small, then (given (2)) not only are the smaller paintings small but so too is the larger painting. But that is false; it's only large.

Example two: Imagine a blob of some homogenous gunk. Presumably the kind we want to fall under the appropriate conditions will be 'blob'. Any part of the blob (a 'blob-part') will itself be a blob. So (given (5)) the things we normally think of as instantaneous temporal parts of any blob-part will be blob-like, ergo will also be instantaneous temporal parts of the larger blob. But

the instantaneous temporal parts of the blob-parts will be small, and those of the whole blob will be large. Thus (given (2)) the larger blob of homogenous gunk turns out to be both large and small at all the times that it exists. This is false, for it is merely large at any given time.

So not any old kind will do for figuring out what the temporal parts of something are. The aim, then, would be to restrict which kinds would be relevant (and find some general conditions X that picked out such kinds). Here are the only two ways I can see of how to go about this:

Way one: In each of the above cases, the *K*-like thing that erroneously turns out to be an instantaneous temporal part (e.g. the person-like slice of the baby) is itself a part of a *K*-like part of the perduring object (e.g. the person-like slice of the mother). The problem would be solved if such things were ruled out from qualifying i.e. we added to the right hand side of (5) that the putative temporal part must be *K*-like but must not itself be part of a *K*-like part of the perduring whole. But this won't do, for there are situations where such a thing *should* turn out to be a temporal part. Those situations again involve time travel, whereby an object ends up having itself as a part at some time. Effingham [2010] offers just such an example. If we had a 'shrinking machine' we could shrink a cube down by a factor of ten, and then send it back in time. We could then remove a chunk of its past self which is the exact size of the shrunken cube, and insert the shrunken, future, version of the cube where that chunk was removed. The cube is now a part of itself at that time. The cube *is* both large and small at that time (in the same way that Marty *is* sitting and standing at the same time). Given (2), it must have two instantaneous temporal parts, one big, one small and both presumably cube-like. But the small cube-like instantaneous slice will be a part of the larger cube-like instantaneous temporal slice. So we can't rule out the *K*-like temporal part of an object being a part of a *K*-like part of the whole, ergo this proposed amendment to (5) would be too strong.

Way two: We could find a kind that *only* the mother was and not the child (or *only* the painting mosaic was, but not the smaller paintings etc.), and then figure out the conditions that end up selecting such kinds. The problem is that there's no suitable kind that only the mother can be and not the child. For instance, if the mother has DNA structure X, and the child has DNA structure Y, we might think that the kind is 'thing-with-DNA-structure-X'. But it is logically possible for the child to be an exact clone of the mother, so the kind must be restricted further, say 'thing-with-DNA-structure-X-and-born-in-year-Z'. But it is logically possible, through the miracle of time travel, for mother and child to be born at the same time and both be that kind of thing. We can keep going on in this vein. As we restrict the conditions in the first conjunct that a *K* must meet in order to count as the relevant kind, we introduce ever more exotic counterexamples. What we would need would be a kind that, like Quine's Pegasising, the mother necessarily *uniquely* satisfies. But they would be bizarre kinds. If there were such unique kinds then intrinsic duplicates of objects would not fall under them (if they did, there would be situations where the kind *wasn't* unique, and we'd be back to constructing exotic counterexamples). But if *x* is of unique kind *K*, yet its intrinsic duplicates are not, we have a problem. The only relevant difference between *x*'s instantaneous slices and the slices of *x*'s intrinsic duplicate(s) is that the former are temporal parts of *x* whereas the latter aren't. So the only thing that could make the former *K*-like and the latter not is that the former are temporal parts of *x* whereas the latter are not. But that would make (5) circular, in that we define what it is to be a temporal part of *x* as being a *K*-like slice, whilst defining being *K*-like as being a temporal part of *x*. Alternatively, to avoid circularity we could just not define the term at all, and take the bizarre, unique kind as a primitive. But as Sider's '-like' kinds aren't part of our common-sense view of the world, nor are unique kinds, it'd make for a pretty strange primitive. So strange, one would wonder why you didn't just take 'instantaneous temporal part' as primitive and be done with it (see §4 for more on that option).

So there are two ways to try and make (5) work, and both fail. I can't see any further alternatives, so let us assume that Sider's strategy won't help avoid the problems we began with.

3. Thomson's Definition

Sider's definition is not the only definition. Thomson has an alternative definition that looks like it might help with the problem:

- (6) x is a cross-sectional temporal part of $y =_{df} (\exists T)[y$ and x exist through T & no part of x exists outside T & $(\forall t)(t$ is in $T \supset (\forall P)(y$ exactly occupies P at $t \supset x$ exactly occupies P at $t))$] [Thomson 1983: 207]

So, given (6), something is a temporal part of a whole if and only if it exist throughout a sub-interval of the interval that a perduring whole persists through, and – throughout that sub-interval – exactly occupies the same places as that perduring whole exactly occupies. However, (6) won't work because Past-Marty and Future-Marty still won't be instantaneous temporal parts of Marty. As those parts are exactly located at disjoint regions, it follows from (2) that Marty would be exactly located in two disjoint places at t_3 . That much is fine, but (6) demands that a temporal part exactly occupies *every* place the whole exactly occupies. As there is no instantaneous object that exactly occupies *both* spatial regions that Marty exactly occupies at t_3 , (6) doesn't allow for Marty to have any temporal parts in time travel cases like this. This is easily solved by revising (6) to allow for such multiple location:

- (7) x is an instantaneous temporal part of y at time $t =_{df}$ (i) x is a part of y ; (ii) x exists at, but only at, time t ; (iii) x exactly occupies (at t) a region of space that y exactly occupies (at t).

(7) dodges both of the problems from §1. The first problem can be avoided because Past-Marty (i) is a part of Marty (ii) exists at, but only at, time t_3 and (iii) exactly occupies (at t_3) one of the spatial regions that Marty exactly occupies at t_3 . So, given (7), Past-Marty *is* an instantaneous temporal part of Marty at t_3 (just as we wanted!). Parallel reasoning applies to Future-Marty. The second problem, that Freak-Marty was an instantaneous temporal part of Marty, is avoided as Freak-Marty is exactly located at some region that is the *union* of the regions Marty exactly occupies at t_3 , *not* a region that Marty himself exactly occupies at t_3 , so doesn't meet the third conjunct of (7).

Unfortunately, (7) faces a different problem. Imagine Marty dies, and when he does so he is a slimmer man than he previously was. Further imagine that he becomes a ghost and that the ghost travels back in time to before he died. Next imagine that, at t_3 , the ghost ethereally passes through his past self at t_3 (see the diagram). Past-Marty is the *material* instantaneous temporal part of Marty at t_3 , whereas Future-Marty is now the *ethereal* instantaneous temporal part of Marty at t_3 . Past-Marty exactly occupies (at t_3) some region R , whilst the ghostly Future-Marty, in being slimmer, exactly occupies (at t_3) a sub-region, r , of R . Given (7), Past-Marty and Future-Marty are instantaneous temporal parts of Marty. That much is fine.

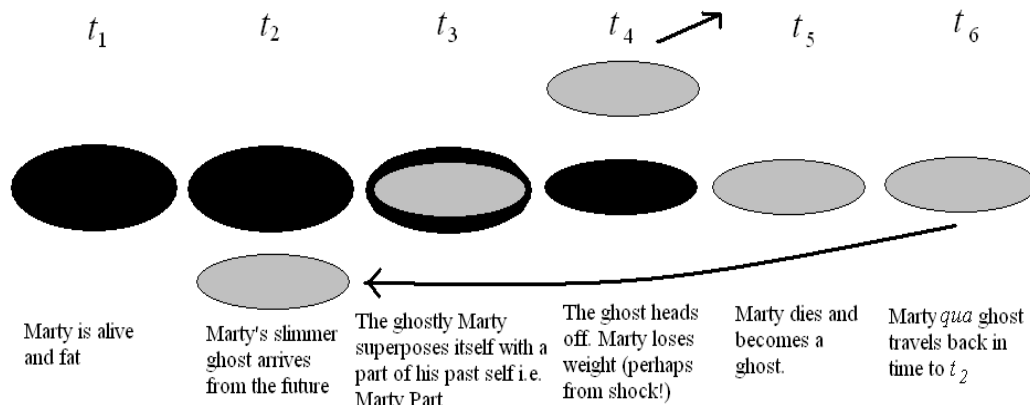


Diagram Marty, his ghost and the time machine

But now consider Marty-Part, that proper part of Past-Marty that exactly occupies r (at t_3) i.e. Past-Marty minus some layers of fat. Marty-Part is a part of Past-Marty, thus by transitivity of parthood is a part of Marty. Marty-Part, in being a part of Past-Marty, exists at, and only at, t_3 . Finally, Marty-Part is exactly located at r (at t_3), a region that Marty is exactly located at (at t_3) in virtue of his ghostly temporal part. So (given (7)) Marty-Part is an instantaneous temporal part of Marty at t_3 . But Marty-Part is an insentient lump of matter (unlike Past- and Future-Marty). So, given (2), when Marty passes through his former self at t_3 it is then true that Marty is an insentient lump of matter. But that's false. At that instant, Marty is a man and Marty is a ghost, but Marty is not an insentient lump of matter. One may find this example unconvincing – it does rely upon ghosts after all. But I do not find the ramifications of the possibility of ghosts on metaphysics to be any less pertinent than the ramifications of the possibility of time travel.

We could avoid the problem by saying that at t_3 Marty is exactly located at region r in virtue of Future-Marty being exactly located there, but *not* in virtue of Marty-Part being exactly located there. Alternatively, Future-Marty's location *explains* Marty's exact location at t_3 whilst Marty-Part's location does not. Following Cameron [2008: 2], interdefine ' P being true explains Q being true' with ' Q is true in virtue of P being true', so treat these alleged solutions as two ways of saying the same thing. With this in mind, (7) can be revised:

- (8) x is an instantaneous temporal part of y at time $t =_{df}$ (i) x is a part of y ; (ii) x exists at, but only at, time t ; (iii) there is some region r , such that y exactly occupies r (at t) directly in virtue⁴ of x exactly occupying region r (at t).⁵

(8) can be revised further by dropping the first two conjuncts. It will only ever be in direct virtue of an instantaneous part of a perdurer exactly occupying a region that the perdurer itself exactly occupies that region at some time. So the first two conjuncts are more or less redundant:⁶

⁴ Following Cameron [2008: 5]: P is true directly in virtue of Q being true $=_{df}$ (i) P is true in virtue of Q being true; (ii) there is no proposition R such that P is true in virtue of R and R is true in virtue of Q .

⁵ I use 'directly in virtue of' instead of 'in virtue of' to fend off the second problem from §1.2. It is not just in virtue of an object's instantaneous temporal part at time t that it is exactly located where it is at t , but also in virtue of any temporal part that has that instantaneous temporal part as a part. But it will only be *directly* in virtue of its instantaneous temporal part. As Freak-Marty is a temporal part of Marty (see $n3$ above), if we used 'in virtue of' instead of 'directly in virtue of' then Freak-Marty *would* count as an instantaneous temporal part of Marty. The revision to 'directly in virtue of' gets us (8), which avoids having to say that, and so allows us to still avoid the second problem.

⁶ An anonymous referee pointed out that the first two conjuncts of (8) aren't redundant if we consider a case where (*a la* Penelope Maddy [1990: 58-60]) x 's singleton is exactly located where x is located. In that case, as the singleton's location is presumably what it is directly in virtue of the location of its member, the

- (9) x is an instantaneous temporal part of y at time $t =_{df}$ there is some region r , such that y exactly occupies r (at t) directly in virtue of x exactly occupying region r (at t).

Presumably, those who endorse (2) do so partly for it to be an explanation of why an object is F at a certain time i.e. explain why objects fall under the predicates they do at that time. But this means (9) gives rise to a worry of circularity. Compare with an ontology of possible worlds. The modal realist wants sentences of the form ‘Possibly P ’ to be explained by possible worlds (and the properties those worlds have). To then say that a possible world is just that thing which explains the truth of ‘Possibly P ’ would be to make the explanation circular. That’s analogous to what goes on given (9). In endorsing (2), the perdurantist will want ‘Barack Obama is exactly located in Washington at 10.01am’ to be explained by Obama’s instantaneous temporal part at 10.01am (and the properties it has). To then say that his instantaneous temporal part is that thing which explains the truth of ‘Barack Obama is exactly located in Washington at 10.01am’ makes the explanation circular. So (9) won’t work.

4. Refusing to give a definition

Continuing the comparison with modal realism, not every modal realist gives a definition of ‘possible world’. Instead, some leave that term as a theoretical primitive. The theory the modal realist ends up with, magical ersatzism, might not be popular but it has been taken seriously [Lewis 1986: 174-91]. The perdurantist might want to do the same, and take ‘instantaneous temporal part’ to be a primitive with no informative definition.

But this would then fail to meet the demands that Sider explicitly imposes upon a definition of instantaneous temporal part, and we’d be back to trying to fend off worries that the notion is unintelligible. Whether that unintelligibility worry is well-motivated in the first place is a good question, but one that lies outside the scope of this paper. It is enough to say that perdurantists have certainly acted as if it were a well-motivated problem (if it wasn’t, why bother with all the definitions Sider, Thomson *et al* provide?). So most perdurantists will be reluctant to go back to the bad old days, when ‘instantaneous temporal part’ was a primitive and there were worries that the perdurantist theory was gobbledygook. So whilst there might be a perdurantist analogue of magical ersatzism we shall assume that it is far better to come armed with a definition of the relevant terms of art, so everyone can be agreed that the theory is intelligible.

5. Perdurantism without (2)

5.1 *The cost of losing (2)*

No definition of ‘instantaneous temporal part’ accomplishes what we need it to, and yet one is required. But it takes both (1) and (2) to bring about the problems discussed in §1.2. Whilst we briefly considered modifying (2) in §2.1, we should now consider rescinding (2) entirely. This is the option I think that the perdurantist should take, although it does come at a price. The first casualty is the (increasingly frustrated) ambition some perdurantists have had to develop a general analysis of what it is for x to be F at t . When I say that we should give up on (2) I do not mean that it needs to be tweaked a bit, in the way that it has been tweaked to take account of sortal properties, abstracted properties etc. Instead I am suggesting that, in light of the time travel scenarios, there is a fundamental problem for developing such a semantic thesis. (2) is false, and no tweaking or fiddling will provide a suitable replacement.

perduring whole ends up being an instantaneous temporal part of the singleton. That’s about as wrong as could be. This would be avoided if we retained the two conjuncts from (8) which (9) drops (as the perdurer is not a part of the singleton, nor do they usually exist at but one instant). However, dropping the conjuncts isn’t integral to what follows, and is only effected to make the following exposition clearer. I don’t think anything hangs on this. If I’m wrong and something does hang on it, then an alternative would be to add a conjunct demanding that x and y must be in the same ontological categories (so events can only have events as instantaneous temporal parts; objects can only have objects as instantaneous temporal parts etc.). In doing so, we’d rule out this counterexample.

Not every perdurantist will be devastated by this loss, but it must still come as a cost (or, more accurately, the privation of a possible benefit). There is a second cost. Some perdurantists relied upon having a workable definition of temporal part akin to (1) for things other than (2). Particularly relevant is an argument in the time travel debate. Elsewhere [2010] I have argued that, given certain time travel scenarios, and equipped with a definition of temporal part (such that Past- and Future-Marty turn out to be instantaneous temporal parts of Marty), we can advance an argument in favour of perdurantism. But if I am right, and there is no such suitable definition of instantaneous temporal part, that argument will now be scuppered.

Thus, there are costs attached to dropping (2). But those costs are not necessarily prohibitive, as the loss of (2) is not going to prevent the perdurantist from embracing many of the other benefits their theory offers (such as dealing with problems of vagueness, material coincidence etc.). So even if one or two motivations are lost (achieving a general semantic analysis of ‘*x* is *F* at *t*’; an argument for perdurantism given the possibility of time travel etc.), it is unlikely that this loss is devastating for most perdurantists.

5.2 A Final Redefinition of Temporal Part

Look again at (1):

- (1) *x* is an instantaneous temporal part of *y* at time *t* =_{df} (i) *x* is a part of *y*; (ii) *x* exists at, but only at, time *t*; (iii) *x* overlaps every part of *y* that exists at *t*. [Sider 2001: 60]

The third conjunct is only introduced in light of endorsing (2). If you endorse (2) you need to ensure that instantaneous temporal parts are things like the (instantaneous) human sized and shaped chunks of my four-dimensional worm rather than, say, the smaller (instantaneous) stomach-shaped chunks that are normally taken to correspond to the instantaneous temporal part of my stomach. In other words, it guarantees that (in the non-time travel cases, at least) my temporal part at *t* is ‘all of me’ that can be found at *t*. This is so that the instantaneous temporal part that I have at this instant turns out to be 5’11” so (given (2)) *I* get to be 5’11” right now. Whereas, were (2) to be true, if an instantaneous chunk of my stomach turned out to be an instantaneous temporal part of me, I’d (erroneously) turn out to be stomach shaped right now. I believe this is the only work that (1)’s third conjunct is doing, as problems such as material coincidence, vagueness, gelling perdurantism with supersubstantivalism etc. can all be solved by just saying that every object is a four-dimensional fusion of a collection of instantaneous objects. To solve those problems it’s irrelevant which of the objects are ‘all of me’ i.e. it’s irrelevant which of those objects counts as an instantaneous temporal part according to (1).

So once we give up on (2) any old instantaneous part of me could be an instantaneous temporal part of me. Whilst this means an instantaneous stomach-shaped slice of me is a temporal part of me, I no longer end up being stomach-shaped at any time for we have dropped (2). As I end up still being a fusion of instantaneous objects, we can still solve the other problems (material coincidence, vagueness etc.) that perdurantism is conscripted in for. So the third conjunct of (1) can be removed and we get:

- (10) *x* is an instantaneous temporal part of *y* at time *t* =_{df} (i) *x* is a part of *y*; (ii) *x* exists at, and only at, *t*.⁷

Note that whether you endorse (1) or (10) the objects that exist remain the same, there’s just a difference over which get called ‘instantaneous temporal parts’ of a certain thing (so the difference is one of semantics, not one of ontology).

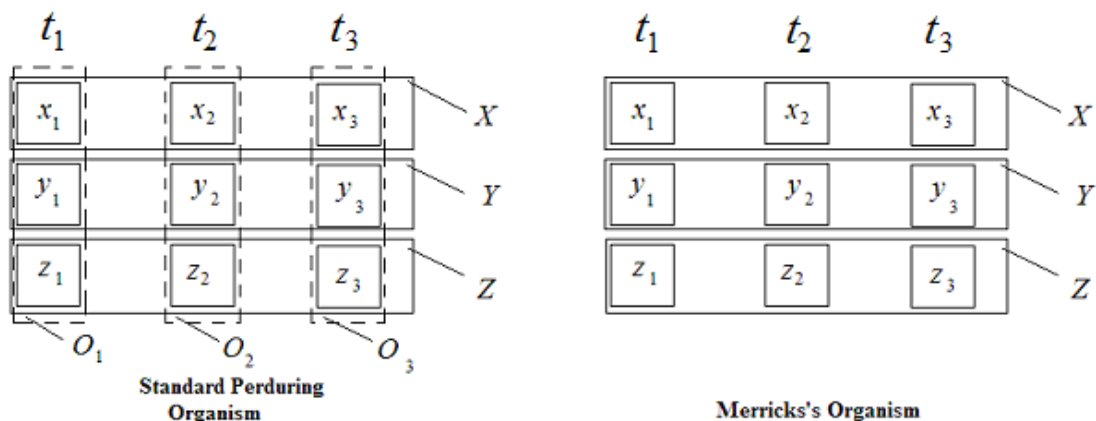
⁷ Following Sider’s lead we can also produce a definition in terms of temporally relativised mereology as an irenic gesture for the benefit of the endurantist (see *n1* above):

(10’) *x* is an instantaneous temporal part of *y* at time *t* =_{df} (i) *x* is a part of *y* at time *t*; (ii) *x* exists at and only at *t*.

(10) must also be coupled with a new definition of what it is to perdure. Presumably, Sider would say that an object perdures if and only if it has an instantaneous temporal part at every instant that it exists at. Given (10), if an endurer had, at every instant that it existed at, a different sub-atomic particle as one of its parts, where each of those particles existed for but an instant, then (even if all its other parts endured over extended intervals) it would perdure. That's not right, so a new definition is needed. Fortunately, given (10), one is forthcoming by saying that *every part* of the perdurer has to have an instantaneous temporal part:

x perdures =_{df} (i) x persists throughout some interval, and (ii) if x exists at instant t then every part of x (at t) has an instantaneous temporal part at t .

Terms like 'temporal part' and 'perdure' are terms of art, so it can never make much difference how we define them. But there are two reasons for recommending that we adopt (10) as the definition of 'instantaneous temporal part' (as well as adopting the new definition of 'perdure'). First, as the superfluous third conjunct in (1) is doing no work, there's no reason to use (1) over (10) other than a fetishistic attachment to a definition of instantaneous temporal part that, having discarded (2), no longer does what it was meant to. The second reason is that the old definitions, unlike my recommended definitions, rule out things from perduring which I think many would want to say should count as perduring. The problem case I have in mind comes from Merricks, who argues that Sider's definition cannot accommodate the possibility of (certain) perdurantists who accept restricted composition [1999: 430-33]. Merricks imagines an organism composed of cells. Each cell persists, and has a temporal slice at each instant that they exist at. The nearby diagram depicts two ways such an organism could be composed. In both cases there are three instants (t_1 , t_2 and t_3). In both cases there are three cells, X , Y and Z , each of which has three temporal parts: so X is composed of x_1 , x_2 , x_3 , Y is composed of y_1 , y_2 , y_3 and Z is composed of z_1 , z_2 and z_3 . Both organisms are composed of X , Y and Z (and thus are composed of x_1 , x_2 , x_3 , y_1 , y_2 , y_3 , z_1 , z_2 and z_3). In the case on the left, composition is unrestricted. In that case, the organism has as parts three things that count as instantaneous temporal parts according to (1): O_1 (composed of x_1 , y_1 , and z_1); O_2 (composed of x_2 , y_2 , and z_2); O_3 (composed of x_3 , y_3 and z_3). The organism on the left, then, has an instantaneous temporal part at every instant it exists at. Those involved in the persistence debate are unanimous that such an entity should perdure, and indeed it does perdure given Sider's definition of perdurance.



But now imagine a perdurantist who had a different principle of composition such that x_1 , x_2 , x_3 composed X , y_1 , y_2 , y_3 composed Y , z_1 , z_2 and z_3 composed Z (so the *atoms* have 'instantaneous temporal parts' given a definition like (1)), and X , Y and Z compose the organism, but that some things did *not* compose e.g. x_1 , y_1 , and z_1 fail to compose O_1 , x_2 , y_2 , and z_2 fail to compose O_2 , and x_3 , y_3 and z_3 fail to compose O_3 . This is what is depicted on the right side of the diagram. So that organism does *not* have instantaneous temporal parts as defined by (1), and so does not perdure

given Sider's original definition. But Merricks thinks we should say it perdures. I agree: whilst we could say something different of Merricks's organism – that it schmerdures rather than pedures or endures, or what have you – it would be perspicuous to have a set of definitions whereby such an organism *did* perdure.

My revised definitions achieve just that. Merricks's organism has six parts at t_1 (x_1, y_1, z_1, X, Y and Z) each of which has an instantaneous temporal part at t_1 (X, Y and Z have x_1, y_1, z_1 respectively for the latter are parts of the former, and each exists only at t_1 , thus fulfilling the criteria laid down in (10); whilst x_1, y_1, z_1 each have themselves as instantaneous temporal parts at t_1 for they are parts of themselves and only exist at t_1). So, at t_1 , every part of Merricks's organism has an instantaneous temporal part at t_1 . *Mutatis mutandis* for all other instants that the organism exists at. So it perdures given my revised definition. Thus, the revisions suggested above avoid Merricks's problems concerning defining perdurantism, making those revised definitions more versatile than Sider's originals.⁸ Nothing too great hangs on this suggested change to the definitions, for they are but terms of arts, but as Sider's original definition does not (having dropped (2)) appear to do any work that my revised set of definitions cannot, I can't but recommend them to you.

6. Conclusion

It would be nice to have a definition of 'instantaneous temporal part' that could make (2) work. However, the extant definitions on offer will not do that, and it is not obvious what alternatives there are. If no alternative can be found then, whilst giving up on (2) may be something some perdurantists are uncomfortable with, it seems there is no other option. So the possibility of time travel does cost the perdurantist enterprise, even if that cost isn't prohibitive. Once we accept those costs, we may as well endorse new definitions of 'instantaneous temporal part' and 'perdure', given that they come with their own benefits, such as dealing with things like Merricks's problematic organism.

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⁸ With thanks to an anonymous referee for pressing me on the fact that these pieces of terminology were only terms of art. That referee also raised concerns about a similar organism composed of $x_1, x_2, x_3, y_1, y_2, y_3, z_1, z_2$ and z_3 , but where those things did not compose X, Y and Z (so it had no persisting parts whatsoever). My definitions say it perdures, but the anonymous referee had worries about this. As such an object would have the same mereological simples as the standard perduring object, would probably be classified as being four-dimensional, and appears to be exactly located at an extended region of spacetime, then I doubt endurantists would want to say that it endured, and I imagine most perdurantists would be fine saying it perduced. So I'm happy for my definition to entail that it perdures.

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