Endurantism and Temporal Gunk

Endurantism

Endurantism is the thesis that at any given instant of time physical objects exist wholly in the sense that they, and all their parts, exist at that time. Endurantists will typically hold that physical objects are three dimensional, only have spatial parts and will believe in diachronic identity in the strictest sense. In particular they will deny that physical objects are extended in the temporal dimension or that they have temporal parts.

It is important here to know what the endurantist means by a temporal part. For her opponent, the perdurantist, objects are taken to be four dimensional regions of space-time, or the material contents thereof. A temporal part of an object is therefore taken to mean a particular four dimensional region of space-time, or its material contents – one which is a sub-region of the intended object, is extended in the temporal dimension, and fills the spatial regions the intended object fills, i.e. reaches its spatial boundaries. A temporal part could also be a time slice of the object, an instantaneous 3D snapshot of the object at a time, in which case it would not be extended along the temporal dimension since it is only one instant wide. We shall discuss whether objects have time slices as parts later. The endurantist on the other hand, does not believe in temporal parts in this sense. She will concede to an object having different parts at different times, but it is only under this weak interpretation that she accepts temporal parts. For example, to describe the loss of a hand, an endurantist might say: at time t object o has part p, and at time $t' > t$, o does not have part p. However, endurantists deny that I have any temporal parts *now*. For an endurantist it *will be the case* that I have different spatial parts, but it is not the case that I *now* have a temporal part with the corresponding spatial difference. If the endurantist is said to believe in any kind of temporal part, it would be the three dimensional time slice that exists now.

Perhaps the way to express the difference between perdurantism and endurantism is that one and not the other posits four dimensional objects and four dimensional parts of objects. This might be too restrictive for the endurantist, for she might still believe in the possibility of space with more than three dimensions, perhaps even infinite dimensional space. It might even be possible for an endurantist to make sense of the notion of many temporal dimensions. Either way, we can make the distinction that perdurantists believe in objects which are extended in the temporal dimension(s) and endurantists do not.

If it is true at all, endurantism must be necessarily true. It appears to be making a fundamental claim about the *nature* of physical objects and time, that such and such a thesis is a feature of a particular ontological category. If something is a characteristic of an ontological category, then how can an entity of this category exist without this feature? There are various attacks on endurantism, some involving the indiscernability of identicals, others approaching the problem from modern physics. In this paper I shall consider possible worlds in which endurantism cannot be true. If such worlds exist, then endurantism, as a necessary claim about the nature of objects and how they persist, is false.

Mereology

So far we have talked about parts (temporal or otherwise) intuitively - it is now time to get bit more rigorous. The area of formal metaphysics dealing with the notion of parthood is called *mereology*. Mereology refers to a collection of axiomatic systems for capturing various inferences about the relation of part to whole. To get a taste, I shall outline a fairly weak mereology. Our language is first order[1] with the only non-logical symbol being '$\leq$' to be read as 'is a part of'. For convenience, we also introduce the defined terms '$\bullet$', '$\perp$' and '$<$' to be read as 'overlaps with', 'is disjoint from' and 'is a proper part of':

Overlap	$x \bullet y \leftrightarrow \exists z[z \leq x \wedge z \leq y]$
Disjoint	$x \perp y \leftrightarrow \neg\, x \bullet y$
Proper Part	$x < y \leftrightarrow [x \leq y \wedge \neg x = y]$

The axioms are:

Reflexivity	$\forall x\ x \leq x$
Anti-symmetry	$\forall x \forall y[[x \leq y \wedge y \leq x] \rightarrow x = y]$
Transitivity	$\forall x \forall y \forall z[[x \leq y \wedge y \leq z] \rightarrow x \leq z]$
Supplementation	$\forall x \forall y[\neg y \leq x \rightarrow \exists z[z \leq y \wedge z \perp x]$
Product	$\forall x \forall y[x \bullet y \rightarrow \exists z \forall w[w \leq z \leftrightarrow [w \leq x \wedge w \leq y]]]$
Sum	$\forall x \forall y[\exists z[x \leq z \wedge y \leq z] \rightarrow \exists z \forall w[w \bullet z \leftrightarrow [w \bullet x \vee w \bullet y]]]$

The first three axioms say that parthood is a partial order. That is

Reflexivity	Everything is a part of itself
Anti-symmetry	If x and y are parts of each other, they are the same
Transitivity	If x is a part of y and y a part of z, then x is a part of z

Conjoined with the assumption that there is something which is a part of everything, and something of which everything is a part, the next three axioms show we are dealing with a Boolean Algebra[2]. Of course these assumptions are controversial, but Boolean Algebras are useful when you are trying to give models of Mereology, as Tarski noted.

Supplementation	If y isn't a part of x, then there is a remainder: a part of y disjoint from x
Product	If x and y overlap, there is an object where they intersect (the biggest object which is part of both)
Sum	If x and y are part of something bigger (they underlap), there is an object which consists of x and y only

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[1] We can have second order mereologies if we wish. This is useful if we want to formulate unrestricted fusion without an axiom schema. The problem with using a first order language here is that, in a mereology with atoms, we expect the size of the universe to be 2^{κ} for some cardinal κ. If κ is finite so is the domain, and if κ is infinite, the domain is uncountable, so either way the domain is never countably infinite. If the mereology is gunky then the universe is always uncountable. But for first order languages there are always countable models if there are infinite models (due to the Löwenheim-Skolem theorem), so first order mereology will always have unintended models.

[2] In the presence of these assumptions we can drop the antecedent of *Product* and *Sum* since every pair of objects overlap and underlap.

We can make our mereology even stronger if we add the axiom of unrestricted fusion, which allows us to collect arbitrary objects into one object (this is actually an axiom schema). An even stronger axiom says that this fusion is unique:

Unrestricted Fusion $[\exists x\varphi \rightarrow \exists! y \forall z[z \bullet y \leftrightarrow \exists x[\varphi \wedge x \bullet z]]]$
For any well formed formula φ with no free occurrences of y or z

As I have already mentioned, to see that these axioms are consistent, we need only take just about any Boolean Algebra as a model – the one most appealing for our purposes would be to consider sets of points in 3D or 4D Euclidean space and interpret $\leq$ as $\subseteq$ (subset). One of the reasons for being concerned with the formal notion of parthood, is that it not only allows us to be rigorous with our reasoning, but allows us to formalise otherwise slippery notions. David Lewis has coined the term 'atomless gunk' for one such notion. We say that an object is gunky iff all its parts have proper parts, and we say an object is an atom iff it has no proper parts. Given this we can consistently add one of two mutually incompatible axioms to our mereology:

Atoms $\forall x \exists y[y \leq x \wedge \neg \exists z[z < y]]$
Gunk $\forall x \forall y[y \leq x \rightarrow \exists z[z < y]]$

One says that every thing is made up of atoms: simples which have no proper parts. The other says that there are no atoms, everything is made up of gunk, which in turn is made up of more gunk and so on and so forth - turtles all the way down. Each but not both of these axioms can be consistently added to the preceding axioms of mereology, i.e. they are independent. To see this simply consider two models: for *Atoms* take sets of points in Euclidean 3-space and subset as parthood, our atoms will then be the singleton sets. For *Gunk* take the non-empty open[3] sets in Euclidean 3-space and subset as parthood.

Gunk Worlds

The possibility of a gunky universe is truly an exotic possibility, but it is exactly this possibility I wish to consider. The notion of gunk certainly seems to be *logically* consistent from the above argument. It is also conceivable and physically plausible (for example, Leibniz thought our universe was gunky). Gunk therefore passes three very strong tests for possibility.

One way in which a universe could contain gunk would be if its space-time was gunky. In fact Russell's co-author on the 'Principia Mathematica', Alfred North Whitehead, thought space and time was gunky. However it is possible that physical objects are gunky even in a space-time which is made of atoms (space-time points). Much like our model for *Gunk* we can just stipulate that no physical object has parts which are not extended in one or more dimensions. When we specified our model for *Gunk*, the underlying set, Euclidean space, was made of points, or atoms. For example this rules out having time slices as parts as I mentioned earlier. Similarly if you are a relationist about space or time,

[3] A set X in 3-space is said to be open iff for all $x \in X$, we can find a $\varepsilon \in R$, such that $B_\varepsilon(x) \subseteq X$ where $B_\varepsilon(x)$ is a sphere of radius $\varepsilon > 0$ with centre x, called the epsilon ball around x.

i.e. you think that space is reducible to objects and their spatial relations, then there is no reason to think that it is impossible for objects to be made of gunk and space of atoms.

Let us focus now on spatio-temporally gunky objects. If physical objects are spatially and temporally gunky then there are no three dimensional objects. According to endurantism all physical objects are three dimensional. Therefore, in these worlds there can be no physical objects. We must therefore conclude that endurantism is false. To summarise, in a world where physical objects are gunky the following holds:

1. Physical objects have spatial parts
2. If physical objects have spatial parts, they have spatio-temporal parts. (Spatial parts *are* spatio-temporal parts).
3. Physical objects are spatio-temporally gunky
4. If physical objects are spatio-temporally gunky and have spatio-temporal parts, there are no three dimensional objects[4]
5. If endurantism is true all physical objects are three dimensional
6. Therefore, if endurantism is true, there are no physical objects.

Although this argument appears to be valid, it could be construed as question begging. To say that an object is spatio-temporally gunky implies that all its temporal parts have proper parts. This sits consistently with physical objects having no temporal parts, but if we want to allow them to have spatial parts at a time slice we have an inconsistency, since endurantism would imply that the object occupied an instant wide time slice, and nothing more. It could be argued that we have sneaked the existence of temporal parts into the third premise. Furthermore, the third premise could well be false in the actual world - I only introduced it as a possibility. This is a problem because endurantism is necessary and gunky objects are possible, but of course the endurantist could accept the soundness of the argument and simply claim that worlds which have these spatio-temporally gunky things are simply devoid of physical objects. Whatever these gunky entities are, they aren't physical objects.

For these reasons, arguments from spatio-temporally gunky objects are unconvincing. Let us now turn to Whitehead's idea that space-time itself is gunky. This leads to a much more powerful objection to endurantism. If space-time is gunky all its parts are four-dimensional, since each region of space-time will contain a four-dimensional ball (i.e. is open). This conjoined with the commonly accepted fact that objects have spatial parts[5] quickly contradicts endurantism. In any world in which space-time is gunky:

1. Physical objects have spatial parts
2. If physical objects have spatial parts they overlap with space-time.
3. All parts of space-time are four-dimensional
4. Therefore physical objects will have four-dimensional parts.

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[4] To see this it is helpful to think of our model for *Gunk*. Every physical object corresponds to a non-empty open subset of R^4. They are non-empty because they have spatio-temporal parts. Let X be the set of points corresponding to a physical object, then since X is non-empty it contains an element x. By the openness property there is a 4D epsilon ball around x inside X, therefore X has a 4D subset (i.e. a 4D part, which means X itself is 4D).

[5] See [7] for an alternative view.

So far we have reasoned from the fact that objects have spatial parts to the conclusion that they have temporal parts in gunk worlds. To talk about objects being spatio-temporally gunky or space-time being gunky involves treating space-time as some kind of connected entity. However, treating space-time in this way seems to be at odds with the endurantist view of space and time in which time is fundamentally different from space. Our discussion of spatio-temporal gunk has required a minimal amount of four dimensional talk. If the endurantist rejects the coherency of such talk altogether then there is little hope of formulating the argument. However, I feel that a theory that does not have the vocabulary for four-dimensional talk, whether or not it has a four dimensional metaphysics, is an untenable theory. It is in this vocabulary that most modern physics is phrased, and if the endurantist world view does not account for this then it is so much the worse for it.

Let us try to respect the endurantist view of time, and briefly note an account in which time is gunky, but the spatial dimensions may or may not be gunky. For a good account of temporal gunk see [5] and [8] especially chapters I.3 and I.4. For a physical object, x, the endurantist claims that at any instant t, x is wholly present at t. Here a more general difficulty presents itself: if time were gunky there would be no instants, so how would the endurantist phrase here position? It is tempting to say that at any interval of time, (a, b), x is wholly present at (a, b). For time with instants, Merricks [4] suggests we analyse 'x is wholly present at t' as 'all of x's parts exist when time t is present'. The equivalent analysis with intervals[6] either commits us to temporal parts, or the notion of time indexed properties breaks down altogether for the endurantist.

Conclusion

The possibility of spatio-temporal gunk poses some puzzles for the endurantist. First and foremost, there is the problem of coherently stating the endurantist position when time is gunky. Secondly there is the problem of squaring spatio-temporal gunk with a disbelief in temporal parts and a belief in spatial parts. Two strategies suggest themselves naturally. One would be to deny the possibility of temporal gunk. Another interesting response would be to deny that physical objects even have spatial parts, so that physical objects are simple yet extended in space. If physical objects were completely disjoint from space-time the arguments above would fail. Simons discusses the possibility of extended simples in [7]. This idea that objects and space-time do not overlap also seems to be entailed by relationism about space-time. Whether or not such theories will stand up to scrutiny is an open question, however, for those of us who cannot stomach this rather radical notion of extended simples, there are few options but to accept temporal parts.

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[6] There are slight problems with the notion of 'present' in gunky time. If the interval (a, b) is present, why is it that intervals contained in or containing (a, b) are not present. Perhaps there is no unique present? These matters seem to pose problems for presentism or even the possibility of gunk time depending on your sympathies.

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