# 4 Four-Dimensionalism

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Persistence through time is like extension through space. A road has spatial parts in the subregions of the region of space it occupies; likewise, an object that exists in time has temporal parts in the various subregions of the total region of time it occupies. This view—known variously as four-dimensionalism, the doctrine of temporal parts, and the theory that objects "perdure"—is opposed to "three-dimensionalism," the doctrine that things "endure," or are "wholly present."[1] I will attempt to resolve this dispute in favor of four-dimensionalism by means of a novel argument based on considerations of vagueness. But before argument in this area can be productive, I believe we must become much clearer than is customary about exactly what the dispute is, for the usual ways of formulating the dispute are flawed, especially where three-dimensionalism is concerned.

## 1. What Is Four-Dimensionalism?

We need to look carefully into just what three- and four-dimensionalism amount to. These names for the doctrines, first of all, are poor guides. If by saying that an object is four-dimensional one means that it extends through the fourth dimension—time—then nearly everyone is a four-dimensionalist, because nearly everyone agrees that objects persist through time. That's not controversial; what's controversial is *how* they do so. Perhaps the saying that objects are four-dimensional has a richer meaning, but then we'd need to know what that richer meaning is; the saying itself doesn't suffice. Other obscure phrases are sometimes used to mark the distinction between three- and four-dimensionalism. David Wiggins, for example, rejects four-dimensionalism's application to anything other than

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events by saying that while events occupy periods of time, continuants like persons don't *occupy* time, but rather persist *through* time.[2] If persisting through an interval is different from occupying it, then we need some account of the difference. Yet another poor characterization of the dispute is the claim one sometimes hears that the disagreement is over whether an object at one time is ever ''strictly'' identical to an object at another. This claim about ''strict identity'' isn't at all controversial: since everyone agrees that every object is strictly identical with itself, everyone who accepts the basic phenomenon of persistence over time accepts the existence of objects that exist at one time and are strictly identical with objects that exist at other times. A final reason to have a clear statement of the dispute is that it is sometimes said that the dispute is meaningless, or even merely verbal! Peter van Inwagen, for example, has said of temporal parts: ''I simply do not understand what these things are supposed to be, and I do not think this is my fault. I think that no one understands what they are supposed to be, though of course plenty of philosophers think they do'' (1981, 133). And Eli Hirsch has claimed that the dispute is merely verbal (1982, 188ff.).[3]

In this section I will give a general statement of four-dimensionalism. I hope to phrase that statement in terms that are clear and acceptable to all concerned so that dispute over its truth will be neither confused nor meaningless.[4] Moreover, the dispute will not be merely verbal, since the terms will not shift their meanings in the mouths of the disputants. To rule out the possibility of obscurity, I'll restrict myself to a meager set of primitive notions. They are, in addition to logical and modal notions, just these two: the mereological notion of a part at a time, and the spatiotemporal notion of existing at a time. Each requires comment.

The notion of an object's having a part at a time is familiar: the end of my fingernail is part of me today, but is not part of me tomorrow if I clip it off; a certain plank may be part of the ship of Theseus at one time but not another, etc. Familiar as this notion is, it is *not* the notion of parthood usually discussed by four-dimensionalists. Following Leonard and Goodman's ''Calculus of Individuals'' (1940),[5] four-dimensionalists tend to speak of the parts of an object *simpliciter*, rather than the parts it has at this time or that. This is actually a special case of a more general fact: four-dimensionalists tend to employ an atemporal notion of exemplification of properties and relations. Thus, a four-dimensionalist will say that my current temporal part *is*, atemporally, sitting, sixty-nine inches tall, and wearing a hat; and a four-dimensionalist will say that this temporal part is, atemporally, part of the larger space-time worm that is me. This is not to say that four-dimensionalists reject the notion of change. For the four-

dimensionalist, change is difference between successive temporal parts. I change from sitting to standing, in the intuitive sense of change, because I have a temporal part that sits and a later one that stands. In a similar sense, I change in what relations I bear: I sit in a chair at one time but not another because my earlier temporal part sits (*simpliciter*) in a temporal part of the chair and one of my later temporal parts fails to sit in the corresponding later temporal part of the chair. Similar points hold for mereological change. My fingernail end ceases to be a part of me, in the intuitive sense of ''ceases to be a part of,'' because its later temporal parts are not part of my later temporal parts.

We can think of the four-dimensionalist's notions of atemporal parthood, and atemporal exemplification generally, as being those we employ when we take an ''atemporal perspective'' and contemplate the whole of time. But when discussing objects in time, we typically do not take this atemporal perspective.[6] We say that the end of my fingernail is part of me now, despite the fact that I'll clip it off tomorrow. But if I do clip it off tomorrow, then it is not part of me in the atemporal sense, for it has parts that are not part of me (namely, its future temporal parts after the clipping). The everyday notion of parthood is temporary, rather than atemporal: the fingernail end is part of me *now*. This is not to say that there's anything wrong with the four-dimensionalist's use of the atemporal notion of parthood. A four-dimensionalist can take the atemporal notion as basic, and characterize temporary parthood using that notion:[7]

(P@T) Necessarily, x is part of y at t iff x and y each exist at t, and x's temporal part at t is part of y's temporal part at t.

Here the four-dimensionalist simply treats temporary parthood the same way that she or he generally treats temporary property exemplification. Sitting at a time, recall, is simply taken to involve having a sitting temporal part which is located at that time; having x as a part at a time is having a temporal part located at that time which contains x's temporal part then as a part.

Thus, the four-dimensionalist characterizes temporary parthood in terms of atemporal parthood. The three-dimensionalist, in contrast, will reject this characterization, since it appeals to temporal parts; for a three-dimensionalist, temporary parthood is irreducibly temporally relative. As for the four-dimensionalist's notion of atemporal parthood, at least as applied to objects that persist through time, the three-dimensionalist is likely to deny that it has sense. One cannot say that my arms and legs are part of me *simpliciter*; one must always specify the time at which the part-whole

relation obtains. This is an instance of a more general pattern: while the four-dimensionalist will say that temporary properties such as *being five feet tall* are had simpliciter (by temporal parts), the three-dimensionalist will insist that such ''properties'' are had only relative to times.[8] Of course, everyday *uses* of 'part' could be missing a temporal qualifier, but in such cases 'part of' implicitly means 'part of now'.

This difference in how the notion of parthood is understood raises a problem for typical statements of four-dimensionalism. Those statements are phrased in terms of atemporal parthood, which means that by a three-dimensionalist's lights, they are incomplete, in something like the way 'John is ten feet from' is incomplete. Of course, they are perfectly intelligible if four-dimensionalism is true. But it is desirable to state opposing views in a neutral language, so that the opponents may agree on the identity of the proposition under dispute. Moreover, we do not want to hide four-dimensionalism in the very language we use to raise the question of its truth. So I suggest we employ a language in which mereological concepts are temporally qualified; let us say 'part of at t' instead of 'part of'. Three- and four-dimensionalists will disagree over whether temporary parthood can be accounted for in terms of atemporal parthood (via (P@T)), but will agree on the intelligibility of the notion of temporary parthood; thus, the framework of temporary parthood is neutral.

If parthood is temporally relative, then so must be certain other mereological notions that can be defined in terms of parthood. Four-dimensionalists speak of objects overlapping (sharing a part in common), and of the mereological fusion, or sum, of a class of objects (a fusion of class S is an object that contains every member of S as a part, and is such that each of its parts overlaps some member of S); in our neutral framework we must speak of objects overlapping *at* a given time, and of an object being a fusion of a class *at* a specified time.[9]

In order to state four-dimensionalism I will need, in addition to parthood-at-t, a temporal notion of *existence-at*. The notion is familiar: I exist at the present time but not at times before 1967; Socrates existed in the distant past but does not exist at the present time, etc. As with temporary parthood, there is a principle governing existence-at that is accepted by the four-dimensionalist but not by the three-dimensionalist: an object exists *at* a time iff it has a temporal part that exists at that time.[10]

I distinguish existence-at from quantification. When I say simply ''there is,'' I intend atemporal quantification over all objects, not just those that are located at any particular time. Exists-at is analogous to the spatial predicate 'is located at', rather than to the logician's $\exists$. There is a view in the

philosophy of time which opposes this notion of atemporal quantification. I say that there is such a thing as Socrates, which doesn't exist *at* the current time; but according to *presentists*, there simply is no such object as Socrates. The only objects are presently existing objects. In this paper I'll assume that presentism is false, but this is only to avoid complication: the claims here could all be restated within a presentist framework.[11]

Given just these two notions, existence-at and temporary parthood, we can give a general statement of four-dimensionalism. As I see it, the heart of four-dimensionalism is the claim that the part-whole relation behaves with respect to time analogously to how it behaves with respect to space: just as things have arbitrary spatial parts, they likewise have arbitrary temporal parts. When applied to space, the idea that things have arbitrary parts means, roughly, that for any way of dividing the region of space occupied by a given object, there is a corresponding way to divide that object into parts that exactly occupy those regions of space.[12] Applied to time, the idea is that for any way of dividing up the lifetime of an object into separate intervals of time, there is a corresponding way of dividing the object into temporal parts that are confined to those intervals of time. This latter claim may be captured in a concise thesis as follows. Say that the *time span* of an object, x, is the set of times at which x exists; and suppose that we have two disjoint subsets of the time span of x, $T_1$ and $T_2$, whose union is T. What we want to say is that there are two objects, $x_1$ and $x_2$, whose time spans are $T_1$ and $T_2$, respectively, that "add up to" x. But since we are using temporally qualified mereological terms, we cannot simply say that x is the fusion, atemporally, of $x_1$ and $x_2$. Instead we say that at every moment of $T_1$, x and $x_1$ have the same parts; and similarly for $T_2$ and $x_2$. We have, then, the following

*Thesis of Temporal Locality*: Necessarily, for any object x, and for any non-empty, non-overlapping sets of times $T_1$ and $T_2$ whose union is the time span of x, there are two objects $x_1$ and $x_2$, such that (i) $x_1$ and x have the same parts at every time in $T_1$, (ii) $x_2$ and x have the same parts at every time in $T_2$, and (iii) the time span of $x_1 = T_1$, while the time span of $x_2 = T_2$.[13]

Evidence that the Thesis of Temporal Locality correctly captures what four-dimensionalists want to say comes from the fact that the Thesis of Temporal Locality entails the doctrine that objects have temporal parts. We first need a definition of 'temporal part'. The temporal part of x at time t is sometimes defined as the part of x that exists only at t and has the same spatial location as x; but I distrust the appeal to spatial location.

The idea is to ensure that the temporal part of x is a "big enough" part of x; but the spatial definition fails for objects without spatial location. The spatial definition would also fail if an object had multiple parts that had the same spatial location as it (if an object had as a part a "trope" corresponding to its shape, this should not turn out to be a temporal part of that object). I therefore prefer a purely mereological definition:

x is an *instantaneous temporal part* of y at instant t $=_{df}$ (i) x exists at, but only at t, (ii) x is part of y at t, and (iii) x overlaps at t everything that is part of y at t.

This captures the idea that my current temporal part should be a part of me now that exists only now, but is as big as I am now. It should overlap my arms, legs—everything that is part of me now. Though this characterizes instantaneous temporal parts, we could generalize to consider extended temporal parts: an extended temporal part of x throughout interval T is an object whose time span is T, which is part of x at every time during T, and which at every moment in T overlaps everything that is part of x at that moment. Unless otherwise noted, however, by 'temporal part' I'll mean 'instantaneous temporal part'. Given my definition of 'temporal part', the Thesis of Temporal Locality has the desired entailment[14] that an object must have a temporal part at every moment that it exists.[15] (Thus, someone who accepted space-time worms corresponding to, but distinct from, "wholly present objects" without temporal parts would not count as a four-dimensionalist, on my usage.)[16]

Note that a four-dimensionalist could offer atemporal analogs of the Thesis of Temporal Locality and definition of 'temporal part':[17]

Necessarily, for any object, x, and for any non-empty non-overlapping sets of times $T_1$ and $T_2$ whose union is the time span of x, there are two objects $x_1$ and $x_2$, such that (i) x is the fusion of $x_1$ and $x_2$, and (ii) the time span of $x_1 = T_1$, whereas the time span of $x_2 = T_2$

x is an *instantaneous temporal part* of y at instant t $=_{df}$ (i) x is a part of y, (ii) x exists at, but only at t, and (iii) x overlaps every part of y that exists at t

Relative to this atemporal definition of 'temporal part' (and the assumptions about atemporal parthood from Leonard and Goodman's Calculus of Individuals), the atemporal Thesis of Temporal Locality entails that every object must have a temporal part at every moment that it exists;[18] it also has the consequence that every object is the fusion of its temporal parts.[19] In what follows, however, I'll think of four-dimensionalism as being stated using temporally qualified mereological terms.

Notice that according to my definition of 'temporal part', a temporal part of x at t must literally be part of x at t. Temporal parts so defined must therefore be distinguished from what we might call ''ersatz temporal parts,'' pairs of objects and times for instance. While ⟨x, t⟩ may be suitable to play part of the role that the temporal part of x at t is supposed to play,[20] many philosophical uses of temporal parts require that temporal parts literally be parts of objects. This is particularly clear in the use of temporal parts in solving the traditional paradoxes of co-located objects. For example, it is said to be possible for a statue and the lump of clay from which it is made to share spatial location because they overlap by sharing temporal parts. But if the temporal part of x at t were simply ⟨x, t⟩, then numerically distinct objects could never share a single temporal part, for whenever x and y are distinct, so are ⟨x, t⟩ and ⟨y, t⟩.

My four-dimensionalism should be contrasted with other doctrines that sometimes go by the same name. Some may use the term for the view that time is a ''fourth dimension,'' analogous in various ways to the spatial dimensions; my usage is narrower, and concerns just one analogy between time and space concerning persistence and parthood. Moreover, on my usage, four-dimensionalism does not imply that facts about temporal parts are ''prior to,'' or more ''fundamental'' than, facts about continuants. It does not imply that continuant objects are in any sense constructed from their temporal parts. Nor does it imply that identity over time is ''reducible to temporal parts,'' in the sense of David Lewis's ''Humean Supervenience.'' Humean Supervenience implies that all facts (in worlds suitably like the actual world) supervene on the distribution of ''local qualities'' throughout spacetime; but local qualities would be instantiated by temporal parts; and so facts about temporal parts would determine all facts about identity over time. The Thesis of Temporal Locality implies no such supervenience; it merely implies that the temporal parts must exist. In particular, the Thesis of Temporal Locality is consistent with there being nonqualitative ''unity,'' or ''genidentity'' relations, and so the Kripke/Armstrong rotating homogeneous disk/sphere is no counterexample.[21] These questions of priority, reducibility, etc. are important questions about temporal parts, but they must be separated from the more basic question of whether temporal parts exist at all. It is thus ''minimal'' four-dimensionalism that is my concern.

## 2. What Is Three-Dimensionalism?

I turn now to the statement of three-dimensionalism, whose defenders deny the analogy between persistence through time and spatial extent.

Friends and foes alike often characterize that doctrine as the view that an object is ''wholly present'' at every moment of its existence. We have D. H. Mellor:

> things are wholly present throughout their lifetimes. (1981, 104)

Peter Simons:

> At any time at which it exists, a continuant is wholly present. (1987, 175)

George Graham, who though he rejects three-dimensionalism thinks it our ''everyday'' view:

> we usually think . . . that at any time at which a person exists the whole or entire person exists at that time. (1977, 309)

Paolo Dau:

> On the three-dimensional conception, the entire object is to be found at each instant that it exists. (1986, 464)

David Wiggins:

> questions of continuity and persistence that perplex our habitual modes of thought about identity and difference . . . [need] answers given in language that speaks as simply and directly as natural languages speak of proper three-dimensional continuants—things with spatial parts and no temporal parts, which are conceptualized in our experience as occupying space but not time, and as persisting whole *through* time. (1980, 25)

And finally, David Lewis:

> Let us say that something *persists* iff, somehow or other, it exists at various times; this is the neutral word. . . . [Something[ *endures* iff it persists by being wholly present at more than one time. . . . [M]any would favor the view that [a person, e.g. Hume] endures, wholly present at every time of his life, so that those times . . . overlap by having him as a shared part. (1986a, 202 and 210)[22]

The suggestion in these quotations, then, seems to be that for any (continuant) x, and any time t, if x exists at t then x is ''wholly present'' at t. (The restriction to ''continuants''—things like persons, planets, protons, medium-sized dry goods, etc.—is necessary since three-dimensionalists often admit that *some* objects, events for example, do have temporal parts.)

This is an unfortunate way to formulate three-dimensionalism. What is it for an object x to be ''wholly present'' at time t? The idea is presumably that every part of x must exist at t. But every part at what time? For three-dimensionalists, the parthood relation is temporally relative, and so ''every part of x exists at t'' is incomplete since 'part of' is temporally unqualified.

There are various ways to fill in the temporal qualifier. We might take the claim that x is wholly present at t to mean that everything that is part of x *at t* exists at t; the slogan then amounts to the following:

(WP1) Necessarily, for every x and every time t at which x exists, every part of x at t exists at t.

The trouble with (WP1) is that it is utterly trivial—no one would deny that a part of an object at a given time must exist then—whereas the claim that an object is wholly present at every moment of its existence is supposed to mark a point of controversy between three- and four-dimensionalists. A four-dimensionalist who defined temporary parthood via (P@T) would accept (WP1).

A more likely sense of 'wholly present', my intended sense from now on, may be defined as follows:

(WP) x is *wholly present* at t $=_{df}$ everything that is at any time part of x exists and is part of x at t.

But on this reading the claim that objects are always wholly present becomes:

(WP2) Necessarily, for every x and every time t at which x exists, everything that is a part of x at some time or other exists and is part of x at t.

This makes three-dimensionalism too strong, for (WP2) entails the impossibility of gain and loss of parts. Granted, *some* three-dimensionalists would accept this consequence, most notably Roderick Chisholm (see his 1976, app. B). But most three-dimensionalists are not mereological essentialists, and so mereological essentialism shouldn't be *built into* the statement of three-dimensionalism.

What, then, is three-dimensionalism? Here are some theses (note that 'wholly present' in (WP6) and (WP7) is intended in the sense of (WP)):[23]

(WP3) Necessarily, there are no temporal parts.

(WP4) Necessarily, nothing that exists for more than an instant ever has a temporal part.

(WP5) Necessarily, for any object x, and for any non-empty, non-overlapping sets of times $T_1$ and $T_2$ whose union is the time span of x, there are *no* two objects $x_1$ and $x_2$, such that (i) $x_1$ and x have the same parts at every time in $T_1$, (ii) $x_2$ and x have the same parts at every time in $T_2$, and (iii) the time span of $x_1 = T_1$, while the time span of $x_2 = T_2$.

(WP6) In the actual world, small particles (for example, electrons) are wholly present throughout their lifetimes.

(WP7) It is possible that some object is wholly present at more than one time.

None is completely satisfactory as a general statement of three-dimensionalism.

(WP3) cannot be a correct statement of three-dimensionalism because many three-dimensionalists will admit the possibility of instantaneous objects, objects that appear only for an instant and then disappear. Such objects would be temporal parts of themselves.

As for (WP4), imagine a lump of clay that gets made into a statue-shape for only an instant (by a god, say). It seems to me that some three-dimensionalists might want to say that in that instant, a statue comes into being, but immediately goes out of existence. After all, many three-dimensionalists say that when a lump of clay becomes statue-shaped for some extended period of time and then gets squashed, a statue comes into being for that period of time; the instantaneous statue would be a limiting case. I'm not myself claiming that instantaneous statues are possible, but it seems to me that they aren't inconsistent with the ''picture'' three-dimensionalists seem to accept, and so shouldn't be ruled out automatically by our statement of three-dimensionalism. But this case would violate (WP4), for the statue would be a temporal part of the lump. As defined above, a temporal part of the lump at t is anything that (i) is part of the lump at t, (ii) exists only at t, and (iii) overlaps at t everything that is part of the lump at t. Condition (ii) is clearly satisfied. As for condition (iii), at the time in question, the lump and the statue are made up of the same subatomic particles; thus, anything that is part of the lump then will share subatomic particles with the statue. Finally, condition (i) can be argued for as follows. The following is a temporally relativized analog of a principle from the Calculus of Individuals (see note 9), and is surely correct:

(PO) If x and y exist at t, but x is not part of y at t, then x has some part at t that does not overlap y at t.

As I just mentioned, the statue and the lump at the time in question are made up of the same subatomic particles; thus, every part of the statue at t will, at t, share subatomic particles with, and thus overlap, the lump. By (PO), (i) then follows.[24]

A similar example shows (WP5) to be unsuitable. Suppose a certain lump of clay is created in statue shape, and after persisting in this form for

a while, gets instantaneously altered to a distinct statue shape, which it retains until being annihilated some time later. Many three-dimensionalists will want to say that in this example, in addition to the lump of clay we also have two statues, one that comes into being when the lump is created, and another that replaces the first statue at the time the lump changes shape. If so, then we have a violation of (WP5), for arguments similar to those given in the previous paragraph establish that the lump has the same parts as the first statue at all times during the first portion of its life, and has the same parts as the second statue at all times during the second portion.

(WP6) is a more likely candidate, but I still have my doubts. First, its restriction to small objects makes it too weak to count as a general statement of three-dimensionalism. Three-dimensionalists seldom confine their remarks to subatomic particles; they say that macroscopic objects such as persons are wholly present over time. Secondly, (WP6) seems too empirically bold. What if scientists discovered that subatomic particles are constantly in flux, exchanging parts at every moment? Would those who accept the intuitive three-dimensionalist picture need to change their minds? The impression one gets from reading Wiggins, van Inwagen, etc. is that three-dimensionalism would not be falsified by such empirical research. Moreover, no such thesis about actuality would be a conceptual thesis about the nature of identity over time.[25]

The final and weakest thesis on the list, (WP7), will, I believe, be accepted by all three-dimensionalists, for three-dimensionalists will accept that while persons *in fact* gain and lose parts, they might not have; and while it could be that subatomic particles are constantly in mereological flux, it is at least possible that they are not. But there is a nagging feeling that something is missing. (WP7) does not contain a universally applicable, positive claim about the essential nature of identity over time! Is the positive picture of identity over time one gets from reading the writings of three-dimensionalists a mere mirage?

A three-dimensionalist might give up on the attempt to give a mereological account of an object's being wholly present and understand that notion in some other way. One wonders whether 'wholly present' would then be an apt term. Moreover, attempts like this tend towards the obscure: recall Wiggins's distinction between occupying a region of time and persisting through that region (and see note 2). But regardless of non-mereological disputes we could consider, we do have a clearly formulated mereological dispute at hand that is worth considering: that of

whether four-dimensionalism is true. For whatever else they think, three-dimensionalists reject the Thesis of Temporal Locality, together with its implication that all objects must have temporal parts.

## 3. In Defense of Four-Dimensionalism

Four-dimensionalism is often supported by appeal to its utility in solving various traditional puzzles about identity over time. While I fully endorse this line of reasoning,[26] I would like to develop a new, more direct argument.

### 3.1 Unrestricted Mereological Composition

My argument for four-dimensionalism will be parallel to an argument for a different thesis: the principle of unrestricted mereological composition, according to which any class of objects whatsoever has a fusion. In the present section I develop in detail the argument for unrestricted composition, and then in the final two sections I show how a parallel argument for four-dimensionalism may be constructed. The arguments make some assumptions, most notably that vagueness never results from "logic" (that is, from boolean connectives, quantification, or identity). Though I do not say that my assumptions cannot be coherently denied, I do think the assumptions are plausible; I also suspect that they are widely held, even among those hostile to temporal parts. There is, therefore, considerable interest in showing that anyone who accepts the assumptions must accept four-dimensionalism.

A starting point for the argument for unrestricted composition that I will develop is David Lewis's argument for the same conclusion:

> We are happy enough with mereological sums of things that contrast with their surroundings more than they do with one another; and that are adjacent, stick together, and act jointly. We are more reluctant to affirm the existence of mereological sums of things that are disparate and scattered and go their separate ways. . . .
>
> The trouble with restricted composition is as follows. . . . To restrict composition in accordance with our intuitions would require a vague restriction. But if composition obeys a vague restriction, then it must sometimes be a vague matter whether composition takes place or not. And that is impossible.
>
> The only intelligible account of vagueness locates it in our thought and language. The reason it's vague where the outback begins is not that there's this thing, the outback, with imprecise borders; rather there are many things, with different borders, and nobody has been fool enough to try to enforce a choice of one of them as the official referent of the word "outback." Vagueness is semantic indecision. But not all

of language is vague. The truth-functional connectives aren't, for instance. Nor are the words for identity and difference, and for the partial identity of overlap. Nor are the idioms of quantification, so long as they are unrestricted. How could any of these be vague? What would be the alternatives between which we haven't chosen?

The question whether composition takes place in a given case, whether a given class does or does not have a mereological sum, can be stated in a part of language where nothing is vague. Therefore it cannot have a vague answer.... No restriction on composition can be vague. But unless it is vague, it cannot fit the intuitive *desiderata*. So no restriction on composition can serve the intuitions that motivate it. So restriction would be gratuitous. Composition is unrestricted.... (1986a, 212–213)

Lewis's version of the argument may be summarized as follows. (I follow Lewis in speaking of parthood atemporally; I consider temporally relativized parthood in the next section.) If not every class has a fusion, then there must be a restriction on composition. Moreover, the only plausible restrictions on composition would be vague ones. But there can be no vague restrictions on composition, because that would mean that whether composition occurs is sometimes vague. Therefore, every class has a fusion.

My version of the argument will take a different form. My reason for abandoning Lewis's version of the argument is its apparent assumption, reproduced as the first premise of my summary, that if not every class has a fusion then there must exist a ''restriction on composition.'' On a natural reading, a ''restriction on composition'' is a way of filling in the blank in the following schema:

A class, S, has a fusion if and only if _____

such that what goes into the blank is not universally satisfied. That is, a restriction on composition would be an answer to Peter van Inwagen's ''special composition question.''[27] (For example, one answer might be that a class has a fusion iff its members are ''in contact.'') But thus understood, the first premise is subject to the following objection: Perhaps the special composition question has no informative answer because whether composition takes place in a given case is a ''brute fact'' that does not admit of informative analysis.[28]

There are two senses in which composition might be brute, one stronger than the other. In the strong sense, composition does not even supervene on causal and qualitative factors. This seems extremely implausible. How could there be two cases that are exactly alike in terms of causal integration, qualitative homogeneity, etc., but such that objects have a sum in one case, but not in the other? But even if supervenience is admitted, composition might be brute in the weaker sense that there is no natural, finite,

humanly stateable restriction on composition. Since I do not wish simply to reject weak brute composition out of hand, I will approach the argument in a different way.

Let us understand a ''case of composition,'' or simply a ''case'' for short, as a possible situation involving a class of objects having certain properties and standing in certain relations. We will ask with respect to various cases whether composition occurs, that is, whether the class in the case would have a fusion. In summary, my argument runs as follows. If not every class has a fusion, then we can consider two possible cases, one in which composition occurs and another in which it does not, which are connected by a ''continuous series of cases,'' each extremely similar to the last. Since composition can never be vague, there must be a sharp cutoff in this series of cases where composition abruptly stops occurring. But that is implausible. So composition always occurs.

Let us develop the argument more carefully, beginning with the idea of a continuous series of cases. First consider any case, C1, of which many would say that composition occurs in it—the case of a certain class of subatomic particles that are part of my body, for example. Now consider a second case, C2, which occurs after I die and am cremated, in which my molecules are scattered across the Milky Way. Some would say that in C2, composition fails to take place: there is nothing that is made up of these scattered, causally unconnected particles. Next, let us further imagine a finite series of cases connecting C1 and C2, in which each case in the series is extremely similar to its immediately adjacent cases in the series in all respects that might be relevant to the question of whether composition occurs: qualitative homogeneity, spatial proximity, unity of action, comprehensiveness of causal relations, etc. I call such a series a ''continuous series connecting cases C1 and C2.''

My argument's first premise can now be stated as follows:

P1: If not every class has a fusion, then there must be a pair of cases connected by a continuous series such that in one, composition occurs, but in the other, composition does not occur.

I can think of only two objections. The first is based on the claim that composition *never* occurs; for if there are never any cases of composition at all, then there will be no continuous series connecting a case of composition to anything.[29] On this view, which Peter van Inwagen calls ''nihilism,'' there are no composite objects. Peter Unger defends a near relative of this view, and van Inwagen defends the view in the case of nonliving things.[30] It deserves special mention because it admits of a better defense than one

might think. Van Inwagen points out that the shocking consequence that tables and chairs do not strictly speaking exist does not preclude ordinary assertions about tables and chairs being at least loosely speaking true, since they are paraphrasable as complicated assertions about the fundamental particles that ''compose'' the ''tables and chairs.'' However, this response is unsuccessful, for it depends for its success on the *a priori* assumption that the ''objects'' of our everyday ontology (tables, chairs, etc.) are composed of mereological atoms—things without proper parts. This assumption needn't be satisfied; an empirical possibility is that electrons, quarks, etc. are composed of smaller particles, which in turn could be composite, and so on. (I present this argument in detail elsewhere (1993), as an objection to van Inwagen's proposed restriction on composition.)

A second objection to P1 might be based on the fact that not every pair of cases can be connected by a continuous series. No continuous series connects any case with finitely many objects to a case with infinitely many objects, for example.[31] However, it would be implausible to claim that, for example, the jump from finitude to infinity makes the difference between composition and its lack. But rejecting P1 because of such jumps would require claiming something like this, for, nihilism aside, one would be saying that all cases of noncomposition are separated from all cases of composition by a barrier over which no continuous series can cross.

Next let us consider the notion of an ''abrupt cutoff'' in a continuous series. By this, I mean a pair of *adjacent* cases in a continuous series such that in one, composition definitely occurs, but in the other, composition definitely does not occur. The second premise of my argument can then be stated as follows:

P2: In no continuous series is there an abrupt cutoff in whether composition occurs.

This seems intuitively compelling. Recall that adjacent members in a continuous series were said to be extremely similar in certain respects. By including more and more members in each continuous series, adjacent members can be made arbitrarily close to being exactly similar in those respects. Given this, it would be hard to accept the existence of a sharp cutoff, nearly as hard as it would be to reject the supervenience of composition on the relevant factors. It would involve our saying, for example, that although certain particles compose a larger object, if one of the particles had been displaced 0.0000001 nanometers, those particles would have failed to compose any object at all. Of course, sharp cutoffs in the application of a predicate are not *always* implausible–consider the predicate 'are separated

by exactly three nanometers'. What I object to is a sharp cutoff in a continuous series of cases of *composition*.[32]

A possible objection to P2 would be based on precisely stateable topological restrictions on the regions of space that can possibly be occupied by a composite object. For example, one might allow fusions only when the occupied region of space would be connected (that is, when any two points of the region are connectable by some continuous path within the region). But this would seem to rule out too many objects: galaxies, solar systems, etc. More importantly, under the classical physics conception of matter, all macroscopic objects are discontinuous. While this is less clear on a quantum-mechanical picture, we still would not want to say that there would be no macroscopic objects in a classical world.[33]

The final premise of the argument is, I think, the most controversial:

P3: In any putative case of composition, either composition definitely occurs, or composition definitely does not occur.

P1, P2, and P3 together imply the desired conclusion. P1 requires that if composition is not unrestricted, we have a case of composition connected by a continuous series to a case of noncomposition. By P3, there must be a sharp cutoff in this series where composition abruptly ceases to occur; but this contradicts P2. It must be emphasized that this is not ''just another Sorites.'' The correct solution to traditional Sorites paradoxes will surely involve in some way the claim that there is a region in which the relevant predicate ('is a heap', 'is bald', etc.) neither definitely applies nor definitely fails to apply. There will be a region of indeterminacy.[34] But this is just what P3 prohibits.

I turn now to the defense of P3. I would first like to clarify its intended content. Recall that a ''case'' was defined as involving a *class* of objects. I here mean classes as traditionally conceived, as opposed to ''fuzzy classes.'' Classes must therefore be distinguished from their descriptions, which might not sharply distinguish members from nonmembers. P3 pertains to the classes themselves, not to their descriptions. Thus, indeterminacy of truth value in the sentence 'The class of molecules in the immediate vicinity of my body has a fusion' would not be inconsistent with P3. In virtue of its vagueness, the subject term of this sentence fails to refer uniquely to any one class. Also note that P3 isn't concerned with the nature of the resulting fusion, but only with its existence. Given a certain class of molecules, it may well be indeterminate whether it has a fusion that counts as a person. But this isn't inconsistent with P3, for the class may definitely have a fusion that is a borderline case of a person.

Lewis's method for establishing P3 runs as follows. In virtue of the definition of 'fusion' in terms of parthood, we can formulate the assertion that a given class, C, has a fusion as follows:

(F) There is some object, x, such that (i) every member of C is part of x, and (ii) every part of x shares a part in common with some member of C.

(F) can be indeterminate in truth value[35] (relative to an assignment to C) only if it contains at least one term such that it is indeterminate in meaning among various precise alternatives, or ''precisifications.'' For example, a precisification of a two-place predicate would be a two-place relation such that it is always determinate, given a pair of objects, whether it holds between them. It is difficult to see what the precisifications of logical terms, or the predicates 'is a member of' and 'part of', might be. So (F) cannot be indeterminate in truth value.

Lewis's justification of P3 is weakest, I think, in its assumption that 'is part of' cannot be a source of vagueness in truth value.[36] His reason is that it is difficult to see what the precisifications of 'part of' might be. But perhaps this is due to these precisifications not being easily stateable in natural language. *Some* terms, such as the term 'is bald', seem to have easily stateable precisifications, namely, properties expressed by predicates of the form 'has a head with less than n hairs'.[37] But other predicates are different. Surely there are or could be sentences of the form ''$\alpha$ is a person,'' or ''$\beta$ is a table,'' with precisely referring singular terms $\alpha$ and $\beta$, that are indeterminate in truth value. But neither 'person' nor 'table' seems to have easily stateable precisifications. So we should be wary of concluding that a predicate cannot be a source of vagueness from the fact that we can't think of what its precisifications might be.

Fortunately, P3 may be supported without making any assumptions about parthood, for if there were vagueness in whether a certain class had a fusion, then there would be vagueness in how many concrete objects would exist, which is impossible. Let us stipulatively define concrete objects as those which do *not* fit into any of the kinds on the following list:

- sets and classes
- numbers
- properties and relations
- universals and tropes
- possible worlds and situations

If I've missed any ''abstract'' entities that you believe in, feel free to update the list. Suppose now for reductio that P3 is false—that is, that there can sometimes be vagueness in whether a given class has a fusion. In such a

case, imagine counting all the concrete objects in the world. One would need to include all the objects in the class in question, but it would be indeterminate whether to include another entity: the fusion of the class. Now surely if P3 can be violated, then it could be violated in a world with only finitely many concrete objects. But consider what we may call ''numerical sentences''—sentences asserting the existence of particular finite numbers of concrete objects. A numerical sentence asserting that there are exactly two concrete objects, for example, looks like this (where the predicate Cx means 'x is concrete'):

$\exists x \exists y[Cx \,\&\, Cy \,\&\, x \neq y \,\&\, \forall z(Cz \rightarrow [x = z \vee y = z])]$.

If it is indeterminate how many concrete objects there are in a world with only finitely many concrete objects, then some numerical sentence must be neither definitely true nor definitely false. But numerical sentences contain only logical terms and the predicate 'is concrete'. The latter predicate presumably has precise application conditions since it was simply defined by the list given above, which consists of predicates expressing fundamental ontological kinds that do not admit of borderline cases. And even if one of the members of the list is ill defined or vague in some way, then the vagueness is presumably of a kind not relevant to my argument: any way of eliminating the vagueness would suffice for present purposes. As for the logical terms, I accept Lewis's view that they cannot be a source of vagueness either. More carefully, by saying that logic cannot be a source of vagueness, I mean that any sentence containing only logical expressions and predicates with no borderline cases (such as 'is concrete') must be either definitely true or definitely false.

The view that logic is non-vague is extremely compelling; indeed, one would be inclined to cite logical concepts as *examples* of precision. Consider the logical concepts case by case: boolean connectives, quantifiers, and identity. At the very least, in no case is there evident indeterminacy in the way that there is for terms like 'bald', 'heap', etc. *Restricted* quantification is admittedly sometimes vague, for the restriction can be vague: one could be quantifying only over objects in one's ''immediate vicinity,'' for example. But in the present context, the quantifiers are intended to be entirely unrestricted, since the issue in this section is whether for any class, there is in the most unrestricted sense a fusion. There are those who say that objecthood itself is vague, and thus that even an unrestricted quantifier can be a source of vagueness. I find this doctrine obscure, though I admit that I have no argument against it. As for identity, identity *sentences* can clearly have vague truth conditions when they have singular terms that are indetermi-

nate in reference—''Michael Jordan is identical to the most popular human being,'' for example. But the only singular terms at issue here are variables relative to assignments, which are not indeterminate in reference. There are those who say that even without indeterminate singular terms, identity ascriptions can be vague in truth value, despite Gareth Evans's (1978) argument to the contrary. Again, I find this doctrine obscure, but I have nothing to add to the literature on Evans's argument.

The argument for restricted composition, we have seen, leans most heavily on P3, which in turn rests on the view that logic, and in particular unrestricted quantification and identity, are non-vague. While this view is an attractive one, I have had nothing substantive to say in its defense. The present argument, therefore, should be taken as showing that anyone who accepts that logic is non-vague must also accept the principle of unrestricted composition. In virtue of the parallel argument I will construct in the next two sections, everyone who shares this assumption about vagueness must also accept four-dimensionalism.

### 3.2 Composition Questions and Tensed Parthood

The argument of the previous section concerned the question of when a given class has a fusion, where 'fusion' was understood atemporally. But when the truth of four-dimensionalism is in question, for neutrality's sake I have advocated temporally relative talk of parthood. If parthood is temporally relative, then so is the relation *being a fusion of*. This requires us to distinguish various composition questions.[38]

The simplest question is that of when a given class has a fusion at a given time. But we are also interested in what we might call ''cross-time'' fusions—things that are fusions of different classes at different times. These are objects that gain and lose parts. One concept of cross-time summation may be introduced as follows. Let's use the term ''assignment'' for any (possibly partial) function that takes one or more times as arguments and assigns non-empty classes of objects that exist at those times as values; and let's say that an object x is a *diachronic fusion* (''D-fusion,'' for short) of an assignment $f$ iff for every t in $f$'s domain, x is a fusion-at-t of $f$(t). For example, consider any two times at which I exist, and let $f$ be a function with just those two times in its domain, which assigns to each of those times the class of subatomic particles that are part of me then. I am a D-fusion of $f$, since at each of the two times, I am a fusion of the corresponding class of subatomic particles.

A second question of composition, then, is the question of when a given assignment has a D-fusion: given various times and various objects

corresponding to each, under what conditions will there be some object that at the various times is composed of the corresponding objects?[39] A third question would be that of the conditions under which there would be such an object that existed *only* at the specified times. This is the question of when a given assignment has a *minimal* D-fusion, where a *minimal* D-fusion of an assignment is a D-fusion of that assignment that exists only at times in the assignment's domain. I am not a *minimal* D-fusion of the assignment $f$ mentioned above, because I exist at times other than the two times in its domain. To get an assignment of which I am a minimal D-fusion, simply extend $f$ into a function that assigns to any other time at which I exist the class of subatomic particles that are part of me then.

In an intuitive sense, a minimal D-fusion of some objects at various times consists of those objects at those times, and nothing more. Though it has required some machinery to state, the question of which assignments have minimal D-fusions is far from being remote and technical. Indeed, we can restate this question in the following woolly yet satisfying fashion: *Under what conditions do objects begin and cease to exist?* Suppose we make a model of the Π-shaped part of Stonehenge out of three toy blocks, $b_1$, $b_2$, and $b_3$, by placing one on top of two of the others at time $t_1$; suppose we separate the blocks a few minutes later at $t_2$. Is there something that we brought into existence at the first time and destroyed at the second? This is the question of whether a certain assignment has a minimal D-fusion—namely, the assignment that assigns the class $\{b_1, b_2, b_3\}$ to every time between $t_1$ and $t_2$.

### 3.3 The Argument from Vagueness for Four-Dimensionalism

Under what conditions does a given assignment have a minimal D-fusion? I say that all assignments have minimal D-fusions, relying on an argument parallel to the argument for unrestricted composition.[40] Restricting minimal D-fusions would require a cutoff in some continuous series of pairwise similar cases. Just as composition can never be vague, neither can minimal D-fusion. So the cutoff would need to be abrupt, which is implausible. The argument may be precisely formulated as follows:

P1′: If not every assignment has a minimal D-fusion, then there must be a pair of cases connected by a "continuous series" such that in one, minimal D-fusion occurs, but in the other, minimal D-fusion does not occur

P2′: In no continuous series is there an abrupt cutoff in whether minimal D-fusion occurs

P3′: In any putative case of minimal D-fusion, either minimal D-fusion definitely occurs, or minimal D-fusion definitely does not occur

The notion of a "case" must be adjusted in the obvious way. A "continuous series of cases" will now vary in all respects thought to be relevant to whether a given assignment has a minimal D-fusion. These respects might include spatial adjacency, qualitative similarity, and causal relations at the various times in the assignment, and also the beginning and cessation of these factors at various times of the assignment.

The justification of premise P1′ is just like that for P1. As for P2′, an abrupt cutoff in a continuous series of cases of minimal D-fusion—a pair of cases that are *extremely* similar in terms of spatial adjacency, causal relations, etc., but which definitely differ in whether minimal D-fusion occurs—seems as implausible as such a cutoff in a series of cases of composition. An objector might attempt to secure an abrupt cutoff by accepting a sort of mereological essentialism according to which, intuitively, nothing exists but mereological sums, which have their parts essentially and exist as long as those parts exist. If you accept this view then you can restrict minimal D-fusions non-vaguely, for you can say that an assignment has a minimal D-fusion, roughly, when and only when it is the temporally longest assignment for a given fixed class of objects.[41] The idea is that mereological fusions of objects "automatically" come into existence when their parts do, automatically retain those same parts, and automatically go out of existence when any of those parts go out of existence. So if you don't mind this sort of mereological essentialism, you needn't fear my argument. I do mind it, for it entails that nothing ever survives the loss of a part.

Just as topological restrictions on regions of space can provide precise restrictions on composition (although I find them unmotivated), topological restrictions on regions of time can provide precise restrictions on minimal D-composition. I would reject the restriction to *continuous* segments of time on the grounds that we want to accept some objects with discontinuous lives (for example, Hirsch's example of a watch that is taken apart for repairs and then reassembled), but others may disagree.[42] One could precisely restrict minimal D-fusions by disallowing instantaneous objects; only objects that occupy an extended interval would be allowed. I would regard this restriction as unmotivated, but anyone who accepts either of these restrictions on minimal D-fusions may revise my statement of four-dimensionalism accordingly, for my argument for unrestricted four-dimensionalism may easily be adapted to support restricted four-dimensionalism while allowing for the restrictions on minimal D-fusions.

On the restricted version of four-dimensionalism there will be neither temporally discontinuous temporal segments nor instantaneous temporal parts, although there will be temporal segments of arbitrarily small duration. There is little need for a fight here: restricted four-dimensionalism is four-dimensionalism enough.

My argument for P3 was that if it is indeterminate whether composition occurs then it will be indeterminate how many objects there are, which is impossible. I use a similar argument to establish P3′. Indeterminacy in minimal D-composition might be claimed in several situations. But in each case, I will argue, at some possible world there would result ''count indeterminacy''—an indeterminacy in the finite number of concrete objects—which, as I argued above, is impossible, assuming that logic is not a possible source of vagueness. (Recall the distinction between existence-at and quantification. Count indeterminacy is indeterminacy in how many objects *there are*, not merely in how many of the objects there are that *exist at* some specified time. It is the former that I need to argue would result from indeterminacy in minimal D-fusion, because all that my assumption about logic directly rules out is the former.)

I distinguish four situations in which someone might claim indeterminacy in whether minimal D-fusion occurs:

(i) *Indeterminacy as to whether some objects have a fusion at a given time, say, because they are moderately scattered at that time*. This would result in count indeterminacy. For consider a possible world containing some finite number of quarks that at all times are greatly scattered, except for a single time at which they are moderately scattered. Moderate scattering was alleged to result in indeterminacy, so it should have that result in the present scenario at the one time when the objects are moderately scattered. But the objects are much more scattered at other times, so the result would be indeterminacy in how many objects exist at the world in question: there is one more object in the world depending on whether the quarks have a fusion at that time. (Similar remarks would apply if 'scattered' in this paragraph were replaced by various other predicates deemed relevant to the question of whether a class has a fusion at a given time.)

(ii) *Indeterminacy in whether an object that is a fusion at t of certain particles is identical to an object that is a fusion at some other time, t′, of some other particles*. This, too, would result in count indeterminacy. Suppose I undergo amnesia in such a way that we feel indeterminacy in whether ''Young Man Ted is identical to Old Man Sider'' is true. Presumably we will want to say the same thing about this case if it occurs in a world with only finitely

many concrete things. But in this world, if we really do have indeterminacy in whether a certain assignment has a minimal D-fusion (say, one that assigns to times before and after amnesia all my parts at those times), then there will result indeterminacy in the count of the concrete objects there, for if the identity holds then there will be one less object than if the identity does not hold.

(iii) *Indeterminacy in when an object begins to exist*. Again, this would result in count indeterminacy. Suppose, for example, that in some case, C, it is indeterminate when a certain statue comes into existence. Consider next a case much like C, but in which (a) only finitely many concrete things exist, and (b) the molecules that would make up the statue are all annihilated *after* the time at which the statue is alleged to indeterminately exist. Then it will be indeterminate whether the statue exists at all, and hence indeterminate how many things there are at the world in question.

(iv) *Indeterminacy in when an object ceases existing*. This case is similar to the previous case.

We have seen, then, that if any of the offered reasons for there being indeterminacy in whether a given class has a minimal D-fusion are genuine, then we would have to accept that at some possible world with finitely many concrete things, it is indeterminate how many concrete objects exist there. But then there would be a numerical sentence that is neither definitely true nor definitely false. Assuming as I am that no indeterminacy can issue from logic, this is impossible. So P3′ is true: a given assignment must either definitely have or definitely lack a minimal D-fusion. This is not to say that the phenomena adduced in (i)–(iv) are not genuine; they simply must be understood in some way not implying indeterminacy in minimal D-fusion. One way would be as follows: (i) The indeterminacy is due to indeterminate restrictions on everyday quantification. Typically, we do not quantify over all the objects that there are, but only over fusions of objects that aren't too scattered; if objects are borderline scattered at some time, they still definitely have fusions at those times, but we have a borderline resistance to admitting those fusions into an everyday domain of quantification. (ii) This is a case involving three objects. Object 1 begins around the time of my birth and ends at the amnesia, Object 2 begins at amnesia and lasts until my death, and Object 3 lasts throughout this time interval. The name 'Young Man Ted' is indeterminate in reference between Objects 1 and 3; the name 'Old Man Sider' is indeterminate between Objects 2 and 3; hence the identity sentence is indeterminate in truth value. (iii) There are many objects involved, which differ in when they

begin to exist; the term 'the statue' is indeterminate in reference among them; hence the sentence 'The statue begins to exist at t' will be indeterminate in truth value for certain values of 't'. (iv) is similar to (iii).

P1′, P2′, and P3′ jointly imply:

(U) Every assignment has a minimal D-fusion.

But (U) is a powerful claim, for it entails four-dimensionalism! The central four-dimensionalist claim, recall, is the Thesis of Temporal Locality:

Necessarily, for any object x, and for any non-empty, non-overlapping sets of times $T_1$ and $T_2$ whose union is the time span of x, there are two objects $x_1$ and $x_2$, such that (i) $x_1$ and x have the same parts at every time in $T_1$, (ii) $x_2$ and x have the same parts at every time in $T_2$, and (iii) the time span of $x_1 = T_1$, while the time span of $x_2 = T_2$.

Let x, $T_1$, and $T_2$ be as described; $x_1$ is obtained by applying (U) to the assignment that assigns x's unit set to all and only t in $T_1$; similarly for $x_2$.[43] The Thesis of Temporal Locality, then, is true. So too are all its entailments, including the claim that an object must have a temporal part at every moment at which it exists. We have resolved our dispute: four-dimensionalism is true.

## Notes

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1. Contemporary four-dimensionalists include Armstrong (1980), Hughes (1986, sec. 5), Heller (1993, 1992, 1990, 1984), Lewis (1986a, 202–204, and 1983, postscript B), and Quine (1981, 10–13, and 1976). I lump the following philosophers into the three-dimensionalist camp, although the view isn't usually clearly articulated (all share in the rejection of temporal parts, though): Chisholm (1976, appendix A), Geach (1972), Haslanger (1994), Mellor (1981, 104), Merricks (1994), Thomson (1983), van Inwagen (1990b), Wiggins (1979; 1980, 25, 25n. 12, 194ff., and longer note 1.11). It is common for four-dimensionalists to identify everyday objects, such as planets and persons, with aggregates of temporal parts—with "space-time worms" as they are sometimes called. I disagree: as I argue in my 1996a, it is better to identify everyday objects with the short-lived temporal parts, and analyze talk of persistence over time with a temporal version of counterpart theory. But in this paper I ignore

my idiosyncratic version of four-dimensionalism in favor of its more orthodox cousin.

2. Wiggins 1980, 25n. 12. Wiggins goes on to claim that continuants persist through time ''gaining and losing parts.'' But of course the four-dimensionalist will accept that objects can gain and lose parts—I lose a part x when x's temporal part is part of my temporal part at some time, but x's temporal parts are not parts of my temporal parts at later times. Mark Heller, an opponent of the three-dimensional view, thinks of it as a view according to which a physical object is ''an enduring spatial hunk of matter'' that exists *at* different times; a four-dimensional thing, in contrast, merely exists *from* one time *until* another (1990, 4–5). In a similar vein, Peter van Inwagen, a friend of the three-dimensional view, says that a perduring object would have ''temporal extent,'' whereas the concept of temporal extent does not apply to enduring objects (see 1990b, 252). The problem is that the distinctions these authors use are no less obscure than the distinction between three- and four-dimensionalism they are attempting to clarify.

3. I have heard various people claim in conversation that there is no genuine (nonverbal) difference between the views, but Hirsch's is the only claim of this sort in print I know of.

4. Haslanger (1994, 340–341) also notes that the obscurity charge can be answered by mereological definitions, although her statement of the controversy differs from mine.

5. See also Simons 1987, 5–100, on classical mereology.

6. Even three-dimensionalists may admit that sometimes we use 'part of' in an atemporal way, when talking about things that are not *in* time in the same way that continuants are. Examples might include talk of times themselves (''the 1960s are part of the twentieth century''), events, or allegedly atemporal things (''arithmetic is part of mathematics''). The relationship between these uses of 'part' and the notion of parthood I utilize in the text is controversial.

7. Thus, the four-dimensionalist can reply to Ali Kazmi's complaint that four-dimensionalism implies that, for example, my fingernail end is not part of me—the reply is that my fingernail end is part of me *now*, in the sense described in the text. See Kazmi 1990, 231n. 3.

8. This fact forms the basis for Lewis's argument from ''temporary intrinsics'' (1986a, 202–204). My claim that three-dimensionalists must accept a temporally qualified notion of parthood is actually oversimplified; I am ignoring the view of those who ''take tense seriously.'' This is manifested in my assumption that all propositions have permanent truth values; I've assumed that if parthood is not atemporal, then the notion of parthood must be the notion of having a part at a time. But one who takes tense seriously would have a third option: even though parthood is not

atemporal, 'x is part of y' expresses a complete present-tense proposition, which in some sense is not reducible to eternal propositions about parthood-at-t. One particular version of this view, presentism, holds that there are no objects that don't currently exist; for ease of exposition I'm ignoring presentism as well. I ignore these views because (contra Merricks 1995) I take them to be independent of the truth of four-dimensionalism; see my 1996b. My arguments would simply need to be restated in a framework with irreducible tense.

Kit Fine (1994) discusses a quite different way of thinking about atemporal parthood (and other topics related to the present paper), which I will not discuss in this paper.

9. For tensed mereology, the basic notion can be taken to be parthood-at-t. Two objects overlap at a time iff something is part of each then. Where S is a class of objects that exist at t, x is a fusion of S at t iff (i) every member of S is part of x at t, and (ii) every part of x at t overlaps-at-t some member of S. I will assume that parthood-at-t is transitive, that everything that exists at t is a part of itself then, that x is part of y at t only if x and y both exist at t, and that the following principle is true:

(PO) If x and y exist at t, but x is not part of y at t, then x has some part at t that does not overlap y at t.

(This is the temporal analog of a theorem of the Calculus of Individuals; see SCT13 from Simons 1987, 38.) See also Thomson 1983, 213–220, and Simons 1987, 175ff.

The atemporal calculus of individuals contained the ''identity principle,'' according to which mutual parthood entails identity; but I do *not* assume its temporal analog, that no two objects can be parts of each other at a time. This principle will clearly be rejected by the four-dimensionalist, given that 'part-at-t' obeys (P@T), for any two space-time worms that share a temporal part at some time provide a counterexample to each. And even three-dimensionalists sometimes distinguish coinciding statues and lumps of clay; if this is right, then the statue and the lump would be parts of each other. At the time of coincidence, any part of either will share subatomic particles in common with the other, but then, by (PO), they are parts of each other at the time.

10. In fact, there is a distinct notion that a four-dimensionalist might legitimately call ''existence at.'' (For this point, see also Heller 1984, 328–329.) In this other sense, I do not exist at the present time because I do not wholly exist at the present time—that is, because I have parts (namely, future temporal parts) that do not exist at the present time. On the sense of 'existence at' in the text, an object gets credit for existing at a certain time in virtue of its having a mere temporal part that exists at that time. My notion of existence-at thus differs from Heller's—he uses one notion where I use the other. I choose my usage so that three- and four-dimensionalists can accept the same notion of existence-at. It is the sense in the text, not Heller's sense,

that corresponds to the everyday sense of existence at a time, for on Heller's sense I do not exist at the present time (since I have future temporal parts that don't currently exist). Thus, the four-dimensionalist will accept that the term 'exists at', as used in the text, obeys the law:

(E) Necessarily, an object x exists at time t iff some part of x exists at t

(Note that 'part' here is atemporal. Thus, (E) does not contradict the truth that may be put intuitively as follows: ''the parts of an object sometimes outlive that object,'' for that truth concerns the temporary notion of parthood.)

Additionally, in this paper 'some object' and 'every object' range only over things that exist in time; thus, I assume 'existence-at' to be governed by the following principle:

(T) Necessarily, each object exists at some time

Finally, I'll also assume the existence of a set of all the things that exist in time.

11. See Prior 1968 and Adams 1986 on presentism, and my 1996b on the independence of presentism and four-dimensionalism.

12. Some reject this thesis. See van Inwagen 1990a, 74–80, for example.

13. Here and throughout this paper I ignore the view that ordinary objects contain immanent universals as parts. My account is similar to that of Heller 1984, 325–329. See also Lewis 1983, postscript B; Thomson 1983, 206–210; and van Inwagen 1981, 133 and 1990b, 245–248. The version of four-dimensionalism I have stated is a particularly strong one, since it implies the existence of a temporal part for *every* subset of the time set of an object. It allows, for example, instantaneous temporal parts and temporal parts with radically discontinuous temporal locations. One might argue for restrictions of various kinds, for example to temporal divisions that are ''natural'' in some sense, or to temporally continuous intervals. See Wiggins 1980, 24–27, and Mellor 1981, 132–134. I prefer the unrestricted version, although there are certain restrictions with which I have no real quarrel (see section 3.3). Moreover, the prefix 'necessarily' will strike some as too strong. David Lewis, for example, accepts the metaphysical possibility of an object's being wholly present at two different times (see the introduction to Lewis 1986b, x). Haslanger (1994, 340) formulates a restricted version of four-dimensionalism.

14. Here and elsewhere, when I say that something is ''entailed by'' or ''follows from'' something else, I mean that the former follows logically from the conjunction of the latter, the assumptions about mereology and existence-at that I make explicit in notes 9 and 10, and the principles of standard set theory (including the axiom of choice).

15. Proof: Consider any object x at any moment t of its career. If x exists only at t, then x is obviously a temporal part of x at t. Otherwise, apply the Thesis of Temporal

Locality to the sets {t} and the set consisting of all the members of the time span of x except for t—the resulting $x_1$ is our desired temporal part. For $x_1$ exists only at t; moreover, x and $x_1$ have the same parts at t. Thus, since parthood-at-t is reflexive, $x_1$ is a part of x at t that overlaps at t everything that is part of x at t.

16. I thank an anonymous referee for drawing my attention to this point.

17. A more general version of the atemporal Thesis of Temporal Locality would assert that for *any* (possibly infinite) partition of x's time span, there exists a (possibly infinite) set of objects, of which x is the fusion, the members of which are confined to the corresponding members of the partition. In the case of the original Thesis of Temporal locality, the more general formulation follows from the simpler one stated in the text (with the help of the axiom of choice), which in turn follows from a still simpler version claiming that for any single subset of x's time span, there is an object confined to that subset that shares parts with x throughout. I thank Kit Fine for these observations.

18. Suppose that x exists at t. If x exists only at t, x is trivially a temporal part of itself at t. Otherwise, apply the Thesis of Temporal Locality to the intervals {t} and the time span of x − {t}; the resulting $x_1$ is our desired temporal part. For $x_1$ clearly exists only at t. Moreover, since x is the fusion of $x_1$ and the resulting $x_2$, $x_1$ is part of x. Finally, let w be any part of x that exists at t; we must show that $x_1$ and w overlap. w must have a part w′ that exists *only* at t (w′ is w itself if w exists at no time other than t; otherwise apply the Thesis of Temporal Locality to obtain w′.) Since w′ is a part of x and x is the fusion of $x_1$ and $x_2$, w′ must overlap either $x_1$ or $x_2$ at t. But w′ cannot overlap $x_2$, for by (E) and (T) (note 10), $x_2$ would then exist at t. So w′ overlaps $x_1$, and hence w overlaps $x_1$.

19. Clearly, each of x's temporal parts is a part of x. It remains to show that every part of x overlaps some temporal part of x. Let y be any part of x. By (T) (note 10), y exists at some time t; by (E) (note 10) x exists at t as well, and so (see previous footnote) has a temporal part z then; by the (atemporal) definition of 'temporal part', z overlaps y.

20. Ersatz temporal parts are perhaps all we need for the task of stating the search for criteria of identity over time as the search for unity or genidentity relations between temporal parts. (See, for example, the introduction to Perry 1975.)

21. See the introduction to Lewis 1986b on Humean Supervenience. Kripke's example is from an unpublished lecture; Armstrong's sphere is discussed in his 1980, 76–78.

22. Simons's passage comes right after what seems to be a definition: ''a continuant is an object which is in time, but of which it makes no sense to say that it has temporal parts or phases.'' It is clear from context, however, that Simons means to be asserting that everyday objects, such as tables, chairs, people, etc., are continuants.

Lewis has not made the mistake of forgetting the temporal qualifier; rather, he is stating three-dimensionalism within his own framework, and therefore with an unfriendly presupposition: that the part-whole relation is atemporal.

23. I thank an anonymous referee for suggesting that I consider (WP5).

24. What of the following as a formulation of three-dimensionalism?

(WP4′) Necessarily, nothing that exists for more than an instant ever has a temporal part at every moment of its existence.

I would reject this statement along with (WP4), because of a modified version of the example in the text. First, if it is possible for time to be discrete, then we could imagine a lump of clay that takes on a radically different statuesque shape at each moment of its existence. In such a case, a three-dimensionalist might want to hold that a distinct statue is constituted by the lump of clay at each moment of the lump's existence; but these statues would be temporal parts of the lump, falsifying (WP4′). And even if it is impossible that time be discrete, a more exotic example might still be possible, in which a three-dimensionalist might want to say that (WP4′) is violated. Imagine a certain lump of clay with a radically discontinuous shape throughout its entire career. At every instant t of its life, (i) the lump has some statuesque shape S at t, and (ii) there is an interval of time about t, such that at every moment in the interval, if the lump exists at that moment, the lump has at that moment a shape that is quite different from S.

25. Haslanger formulates what she calls the ''endurance theory'' as a claim about actuality (1994, 340), but she does not clarify the meaning of 'wholly present'.

26. I give this sort of support for temporal parts in my 1996a.

27. Actually, the Special Composition Question is slightly different, since it concerns when fusion takes place *at* a given time; see van Inwagen 1990a, ch. 2.

28. Thanks to David Cowles and Ned Markosian here. Markosian defends this claim about composition in his ''Brutal Composition'' (forthcoming).

29. On the usual terminology, a mereological atom is the fusion of its unit class; let us understand ''continuous series connecting cases C1 and C2'' as excluding ''cases'' involving only one atom.

30. See van Inwagen 1990a, 72–73, and chapter 10, and Unger 1979. Unger does not deny the existence of all composite objects; he believes in molecules and certain crystal structures—see 241–242.

31. I thank Earl Conee for this observation.

32. Those happy with the ''epistemic'' view of vagueness, according to which the apparent indeterminacy of vague predicates is simply due to our ignorance, may be happy with a sharp cutoff here, since they already accept similar cutoffs for predicates such as 'heap', 'bald', etc. See, for example, Williamson 1994.

33. I thank John G. Bennett for helpful observations here. Another sort of precise restriction of fusions would be to classes that are sets. This seems to me unmotivated, but if some motivation were produced I wouldn't really mind the restriction.

34. Defenders of the epistemic view of vagueness would disagree here; see note 32.

35. Notice that there are possible sources of truth value gaps other than vagueness, such as ambiguity or failed presupposition; I'll ignore these in the present discussion.

36. Notice that in ruling out 'part of' as a source of vagueness, Lewis is not ruling out all vagueness in *ascriptions* of parthood, for ascriptions of parthood may contain singular terms (for example, 'the outback') that are indeterminate in which object they refer to. (F), however, apparently contains no vague singular terms.

37. Even in this case, stateability is in doubt, given the vagueness of 'head' and 'hair'.

38. See Simons 1987, 183ff, and Thomson 1983, 216–217.

39. Thomson discusses this question (1983, 217).

40. There are some similarities between my argument and arguments contained in Quine 1981 (10) and Heller 1990 (ch. 2, sec. 9).

41. Less roughly: where $S_1$ and $S_2$ are sets of objects that exist at times $t_1$ and $t_2$, respectively, say that pairs $\langle t_1, S_1 \rangle$ and $\langle t_2, S_2 \rangle$ are *equivalent* iff every part-at-$t_1$ of any member of $S_1$ overlaps-at-$t_2$ some member of $S_2$, and every part-at-$t_2$ of any member of $S_2$ overlaps-at-$t_1$ some member of $S_1$. The idea is that $S_1$ and $S_2$ contain, if not exactly the same members, at least the same stuff, just divided up differently. The non-vague restriction is that an assignment $f$ has a minimal D-fusion iff $f$ is a maximal equivalence-interrelated assignment; that is (construing $f$ as a class of pairs), iff (i) every two pairs in $f$ are equivalent, and (ii) if $\langle t, S \rangle$ is equivalent to some member of $f$, then it is equivalent to some member of $f$ whose first member is t.

42. See Hirsch 1982, 22ff, as well as the whole of chapter 1, on different senses of "continuity."

43. Proof: (U) tells us that some object $x_1$ is a minimal D-fusion of the assignment, $f$, with domain $T_1$, which assigns $\{x\}$ to every member of $T_1$. The time span of $x_1 = T_1$, since (a) $x_1$ exists only at times in $f$'s domain, and no time outside of $T_1$ is in $f$'s domain, and (b) $x_1$ contains x as a part and hence exists at every $t \in T_1$. Moreover, where t is any time in $T_1$, $x_1$ is a fusion of $\{x\}$ at t. We now show that $x_1$ and x have the same parts at t: (i) Let y be part of x at t; x is part of $x_1$ at t since $x_1$ is a fusion of $\{x\}$ at t; but then y is part of $x_1$ at t. (ii) Let y be part of $x_1$ at t, and suppose for reductio that y isn't part of x at t. By (PO) (see note 9), y has a part, z, at t that x doesn't overlap at t. Since $x_1$ is a fusion of $\{x\}$ at t, x overlaps every part of $x_1$ at t. But z is part of $x_1$ at t. Contradiction.

Without loss of generality, the result follows.

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# B Exdurance (or Stage Theory)