

## Coinciding Objects and Duration Properties: Reply to Eagle

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### 1. Introduction

In my (2007) I presented a new puzzle for perdurantism<sup>1</sup> (the “type-C puzzle”), and I noted that perdurantists could solve it in various ways. I then defended the main conclusion of the paper:

MC Any perdurantist solution to the type-C puzzle would significantly weaken at least one familiar argument against endurantism.

Antony Eagle develops two perdurantist solutions to the puzzle. One of these, he agrees, poses no threat to MC. He takes the other, however, to be a counterexample to that conclusion. In what follows, I defend MC against Eagle’s challenge.

### 2. The Type-C Puzzle

To state the puzzle, I introduced some technical terminology, which I briefly review. (1) I assumed that parties on both sides of the endurantism v. perdurantism dispute could grasp the two-place predicate ‘exactly occupies’, and that it would turn out to be obvious that a thing *O* exactly occupies a spacetime region *R* iff *O* has (or has-at-*R*) the same size, shape and position as *O*, but that it would not turn out to be obviously impossible for a thing to exactly occupy each of several non-intersecting regions but not their union or any of their proper subregions. (2) I defined a thing’s *path* as the union of the (region or) regions that the thing exactly occupies. (3) I (very informally) defined an *S-region* of an object as an instantaneous spacetime region that corresponds to what we ordinarily think of as a spatial location of that object at some instant in its career; I then claimed that according to endurantism, material objects exactly occupy just their s-

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<sup>1</sup> Roughly, the view that material objects persist by being temporally extended and having different temporal parts at different times. Endurantism, roughly, is the view that material objects persist without being temporally extended or having temporal parts, but rather by being wholly present at each moment of their careers.

regions, whereas according to perdurantism, material objects exactly occupy just their paths. (4) I said that things *x* and *y* *coincide* iff there is a region that they both exactly occupy.<sup>2</sup> (5) Finally, I said that *x* and *y* are involved in a *type C situation* iff *x* and *y* are numerically distinct material objects that have the same path but do not have any of the same s-regions.

I described two main cases that appeared to count as type C situations. I will focus on just one of them here:

**Adam and Abel.** A hydrogen atom, Adam, has a path that follows a closed timelike curve.<sup>3</sup> This closed curve, however, is not a ‘simple loop’; instead it is ‘doubled up’ like the edge of a möbius strip. This allows for Adam, at each moment of its career (or in each of its s-regions), to be chemically bonded to itself, at a *different* moment of its career (or in a different s-region), thus forming a molecule of H<sub>2</sub>, Abel. Adam and Abel apparently have the same path but none of the same s-regions. *Prima facie*, Adam’s s-regions are atom-shaped, whereas Abel’s are all larger and shaped like molecules of H<sub>2</sub>.

This case generates a puzzle for perdurantism that can be solved by shifting to endurantism. In light of the various apparent differences between them (which I discuss below), Adam and Abel are plausibly taken to be numerically non-identical. Moreover, if these objects *perdure* then, since they have the same path, and since perduring objects exactly occupy their paths, the objects coincide (at their shared path), in violation of the ‘anti-coincidence’ principle.<sup>4</sup> But if they

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<sup>2</sup> For simplicity, I am working with a spatiotemporal notion of coincidence when, to be strictly faithful to the views of most anti-coincidentalists, I would need to work with a mereological notion. See note 4 below and my (2007: 178, note 4).

<sup>3</sup> A timelike curve is, roughly, a continuous one-dimensional spacetime region that could be the path of a spatially unextended particle that has mass. It need not be ‘curvy’; it can be straight. It is closed if it forms a loop.

<sup>4</sup> For convenience, we can pretend (as I did in my (2007: 178, note 4)) that this principle is just a ban on spatiotemporal co-location – i.e., that it is the view that it is impossible for there to be a spacetime region that is exactly occupied by two different material objects. In fact, a better approximation of the principle is this: it is impossible for two different material objects to exactly occupy the same spacetime region and be composed of the same things in that region. (Many self-described anti-coincidentalists are happy to allow for the possibility of worlds governed by unfamiliar laws of nature in which non-identical material objects exactly occupy the same region, so long as these objects are not composed of the same things.) Since my case does obviously not involve this sort of co-location without co-composition, the pretence above makes no difference.

*endure*, then since they share none of their s-regions, and since an enduring object exactly occupies only its s-regions, the objects do not coincide, and the anti-coincidence principle is preserved.

Eagle argues that perdurantists can solve the puzzle either by (i) maintaining that, despite appearances, Adam and Abel are in fact identical or by (ii) conceding that they are distinct, but using a non-extensional mereology for spacetime regions to claim that their *paths*, though both entirely composed of exactly the same spacetime points, are *also* distinct, in which case Adam and Abel could perdure without strictly coinciding, as I defined that term above.

The second solution deserves more attention than I can give it here. As Eagle notes, however, it does undermine at least one well-known style of argument against endurantism and so it poses no threat to my intended conclusion, MC. (See his note 40.) The remainder of the paper, therefore, will focus on Eagle's first solution.

### **3. Identifying Adam and Abel: A *Prima Facie* Cost**

Eagle's preferred response to the type-C puzzle is to maintain that Adam and Abel are numerically identical. Moreover, he claims – against MC – that this response does nothing to weaken any of the standard arguments against endurantism. This is a claim that I want to resist.

One of my arguments for the non-identity of Adam and Abel appealed to differences in their 'mass histories': Adam has a rest mass of one unit throughout its two-billion-year-long career, but Abel does not. (Abel's career is just one billion years long, and it has a rest mass of more than one unit throughout that career; this mass history is incompatible with Adam's.)

As far as I can tell, the only viable strategy for resisting this argument is to adopt a 'relativizing' treatment of mass histories. One can hold that my case involves just a single thing whose career can be divided up into temporal parts in different ways. Relative to one such partition (the atomic partition), the thing is a long-lived, not-so-massive hydrogen atom; relative to a different partition (the molecule partition), it is shorter-lived, more-massive molecule of H<sub>2</sub>.

To adopt this view is to hold that while the relevant mass histories may *appear* to be incompatible, intrinsic, monadic properties, they are in fact ‘disguised relations’ that things can bear to partitions.<sup>5</sup> The advocate of this view will reject the following principle:

- (L\*) If a small hydrogen atom with a 2 billion-year-long career and a constant rest mass of 1 unit completely composes a larger hydrogen molecule with a 1 billion-year-long career and constant rest mass of more than 1 unit (in the manner illustrated by my case), then:
- (i) there is a thing that just plain *has* the monadic, intrinsic, non-indexed property being an object that has a rest mass of 1 unit throughout its 2-billion-year-long career [ $M_1$  for short], and
  - (ii) there is a thing that just plain *has* the monadic, intrinsic, non-indexed property being an object that has a rest mass of more than 1 unit throughout its 1-billion-year-long career [ $M_2$  for short], and
  - (iii) necessarily: for any  $x$  and  $y$ , if  $x$  just plain has the monadic, intrinsic non-indexed property being an object that has a rest mass of 1 unit throughout its 2-billion-year-long career and  $y$  just plain has the monadic, intrinsic, non-indexed property being an object that has a rest mass of more than 1 unit throughout its 1-billion-year-long career, then  $x \neq y$ . (2007: 195)

So if one is willing to deny (L\*) and be a relativizer about mass histories, then (so far as the current argument is concerned) one can identify Adam and Abel.

But (L\*) is intuitively plausible, at least initially. Why is denying it any better than solving Lewis’s problem of temporary intrinsics (1986a: 202-204) by being a ‘relativizer’ about shapes and thus denying the following?

- (L) For any material object  $O$ , if  $O$  changes from being bent to being straight, then:
- (i) there is a thing that just plain *has* the monadic, intrinsic, non-indexed property being bent, and
  - (ii) there is a thing that just plain *has* the monadic, intrinsic, non-indexed property being straight, and
  - (iii) necessarily: for any  $x$  and  $y$ , if  $x$  just plain has the monadic, intrinsic, non-indexed property being bent, and  $y$  just plain has the monadic intrinsic, non-indexed property being straight, then  $x \neq y$ . (2007: 195)

If the perdurantist identifies Adam and Abel and denies (L\*), then he must reject our intuitions about the nature of the relevant mass histories. And if he does this, then he should concede that the endurantist can, at a comparable price, reject our intuitions about the nature of the relevant shapes. So, *in the absence of some reason for treating these apparently similar cases differently*,

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<sup>5</sup> The relativizing strategy, like relativizing approaches to shapes and other apparently temporary properties, can be implemented in other ways as well: e.g., by positing an extra argument place in the instantiation relation rather than in the mass histories (or shapes). See Haslanger (2003). I assume that these alternatives do not require separate discussion.

we can conclude that Eagle's preferred solution does significantly weaken Lewis's argument from temporary intrinsics, and that MC stands.

#### 4. Eagle's Attempt to Find A Significant Disanalogy Between the Cases

Is there anything *especially* bad about relativizing treatments of shapes (which deny (L)), some problem for those views that does not apply equally to relativizing treatments of mass histories (which deny (L\*))? This is the crux of the dispute between Eagle and me, and he addresses it the following passage:

What is it to have a career of a certain length? Existing for a certain duration of external time is arguably the fundamental physical quantity that can be possessed non-relationally; but there is no sense in which the careers of Abel and Adam differ in length in external time. The only sense in which Adam has a two-billion-year-long career is in terms of its atomic personal time. Since personal time depends on time travel, what an object's personal time is is not a monadic property but depends, as we saw above, on what sameness-constituting causal relations ground the time travel. In terms of Adam's *molecular* personal time, which involves no same-molecule backwards causal relations, and is thus identical to external time, Adam has a one-billion-year-long career. But there is no reason to think that having different length careers is an incompatible property when we are not measuring length in the same time! One and the same object can have multiple mass histories, relative to the different personal times it has in virtue of the different kinds of things it is. So Adam has a two billion-year-long atomic career, and a one-billion-year long molecular career; we know that the mass of the atom and molecule are the same.

Gilmore considers a similar 'relativizing' approach to mass histories. While he admits that it can succeed, he thinks that if adopted by the perdurantist, that perdurantist cannot in good conscience reject a similar relativizing response on the part of the endurantist to the argument from temporary intrinsics. The cases are importantly disanalogous, however, because the perdurantist should not accept that these relativized mass histories are fundamental physical properties. The only mass history with a fundamental role is the distribution of mass through external time, and in external time the only mass history, shared by Adam and Abel, is  $M_2$ . The endurantist confronted with the problem of temporary intrinsics, by contrast, *cannot* appeal to a fundamental non-relativized notion of an intrinsic property. The perdurantist criticisms of relativizing moves do not apply to the unrelativized mass history in external time, and that mass history is the only one the perdurantist should take as basic. (2009: pp)

Why is denying (L), and being a relativizer about shapes, so much worse than denying (L\*), and being relativizer about mass histories (or, more simply, career-lengths)? The reason, according to Eagle, is that while *external* time lengths, like shapes, are fundamental properties (which, so the thought goes, puts us under a special obligation not to be relativizers about them), *personal* time lengths are not fundamental; and while Abel does have a one-billion-year-long career in external

time, the only sense in which Adam's career has the superficially incompatible length of *two* billion years is with respect to its atomic personal time.

So, in light of the non-fundamentality of personal time (Eagle's suggestion continues), we are free to be relativizers about lengths in personal time, without thereby undermining the argument from temporary intrinsics; and merely by relativizing in this innocuous way, we can resist the argument for the non-identity of Adam and Abel. For we can then say: while it's true that Abel's career has the property having a length of one billion years, it is *not* true that Adam's career has the incompatible property having a length of two billion years; rather, Adam's career merely has the non-fundamental property having an 'atomic personal time' length of two billion years. And that is not enough to establish the non-identity of Adam and Abel, since there is clearly no incompatibility between that non-fundamental property and having a length of one billion years.

To sum up, Eagle's position is apparently this. If Adam's career and Abel's career plausibly had incompatible *fundamental* temporal lengths, then resisting the argument for their non-identity by appeal to some relativizing treatment of those lengths *would* undermine the argument from temporary intrinsics. But they do not plausibly have incompatible fundamental lengths. So the argument for their non-identity can be resisted without undermining the argument from temporary intrinsics.

## 5. Reply

One might wonder whether facts about fundamentality are relevant to the argument from temporary intrinsics in the way that Eagle apparently takes them to be. He suggests that what makes relativizing treatments of shapes so much worse than relativizing treatments of personal time lengths is that the former are so much more fundamental than the latter. This might be doubted. Is it any worse to hold that shapes are relations to times than to hold that apparently

intrinsic aesthetic ‘properties’ such as beauty are relations to times?<sup>6</sup> For the sake of argument, however, I will adopt Eagle’s suggestion: fundamentality matters.

In a nutshell, my response to Eagle is this. It is quite plausible that the relativistic *proper* time length (not merely the Lewisian *personal* time length) of Adam’s career is two billion years, and likewise it is quite plausible that the relativistic proper time length of Abel’s career is one billion years. Since proper time lengths are the most *fundamental* temporal length properties, the fact that Adam’s career and Abel’s career plausibly have incompatible proper time lengths is very significant: for it shows that if one resists the argument for the non-identity of Adam and Abel by adopting a relativizing treatment of the lengths with respect to which their careers appear to differ, then, by Eagle’s lights at least, one *does* undermine the argument from temporary intrinsics!

### 5.1 External time lengths v. personal time lengths

Lewis distinguishes between “time itself, *external* time as I shall call it” and “the personal time of a particular time traveler,” and he sketches a reductive definition of the latter in terms of the former, together with certain notions concerning change and causation (1986b: 69). This distinction generates a more specific distinction between two families of *temporal* (or quasi-temporal) *lengths*: external time lengths and personal time lengths. Since these two families are directly relevant to my dispute with Eagle, I need to say something about each of them.

Begin with external time lengths. In the context of a typical pre-relativistic spacetime, there doesn’t seem to be any question as to which properties count as the external time lengths. One such property is the one that would be expressed by the predicate in the following sentence, if spacetime in our world were Newtonian:

- (i) Bruce’s life *has a length of 95 years*.

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<sup>6</sup> Of course, if you think that beauty is highly fundamental, or if you deny that it is even *prima facie* monadic and intrinsic, then you should try to find a different example.

In relativistic spacetimes, however, there are several candidates for being the external time lengths: the proper time lengths, the inertial-frame-relative temporal lengths, and the so-called ‘cosmic time’ lengths.

**Proper time lengths.** Timelike curves and the careers of persisting objects have proper time lengths. Roughly, the proper time length of an object’s career is the property that would be measured by a clock that was carried along with the relevant object from the beginning of its career to the end. One famous feature of relativistic spacetimes is that different timelike curves or careers linking the same two points in such a spacetime will not in general have the same proper time lengths. (This gives rise to the ‘twins paradox’.) Crucially, the proper time length of a given curve or career is an invariant, not a frame-relative, matter; facts involving these properties are, so to speak, built into the metrical structure of the spacetimes in question. One proper time length property is expressed by the predicate in

- (ii) Bruce’s life *has a proper time length of 95 years.*

**Inertial-frame-relative temporal lengths.** The concept of an inertial reference frame is often invoked in presentations of special relativity, and associated with it is the concept of an inertial-frame-relative temporal length. Roughly put, where  $f$  is an inertial reference frame, the length-in- $f$  of a given continuous timelike curve or career  $p$  is the temporal distance between the beginning of  $p$  and the end of  $p$  as measured by an observer at rest in  $f$ . In other words, it is the proper time length of a timelike curve  $p^*$  at rest in  $f$ , where  $p^*$  runs from the hyperplane of simultaneity-in- $f$  that intersects the beginning of  $p$  to the hyperplane of simultaneity-in- $f$  that intersects the end of  $p$ . Some inertial-frame-relative length properties are expressed by the predicates in the following sentences:

- (iii) Bruce’s life *has a length of 95 years with respect to inertial frame  $f_1$ .*
- (iv) Bruce’s life *has a length of 50 years with respect to inertial frame  $f_2$ .*

**‘Cosmic time’ temporal lengths.** Typical relativistic spacetimes admit of many different foliations, where a foliation is a partition of the spacetime into a set of non-overlapping ‘global



time-slices', or maximal spacelike hypersurfaces. But some spacetimes allowed by general relativity, while admitting of many foliations, have exactly one 'preferred' foliation that stands out from the rest by virtue of its geometrical properties. The rough idea is described by Michael Lockwood in the following passage:

[the] *fundamental observers* . . . are observers whose state of motion coincides with average motion of matter in their own local regions of the universe, a region sufficiently large for the motion within it to be dominated by the recession of the local galaxies, in accordance with the overall expansion of the universe. It then follows that the local proper times of all these fundamental observers can be fused together to form a single coordinate time for the universe as a whole, known as *cosmic time*. (2005: 116)

Associated with cosmic time will be a family of temporal length properties; call them the *cosmic time lengths*. On the assumption that cosmic time is definable in our spacetime, one such property is expressed by the predicate in

(v) Bruce's life *has a length of 95 years with respect to cosmic time*.

Roughly, the cosmic time length of a given continuous timelike curve or career will be temporal distance between its beginning and end, as measured by one of the so-called 'fundamental observers' that Lockwood mentions.

The standard view among those who take relativistic spacetime seriously (a group that includes Eagle, I suspect) is that proper time lengths are more fundamental than frame-relative temporal lengths or cosmic time temporal lengths, on the grounds that the second and third families are defined in terms of the first. Relatedly, there are relativistic spacetimes (e.g., the Gödel spacetime<sup>7</sup>) in which proper time lengths are instantiated but frame-relative and cosmic time temporal lengths are not (due to the absence of inertial reference frames and cosmic time); but there are no relativistic spacetimes in which the opposite holds: you can have proper time lengths without either of other two families, but not vice versa. Insofar as external time has any claim to fundamentality, then, it seems to me that the best candidates (in a relativistic spacetime) for occupying the role of the *external time lengths* are the *proper time lengths*.

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<sup>7</sup> For discussion, see (e.g.) Gödel (1949), Earman (1995), and Lockwood (2005).

Now we can turn from external time lengths to personal time lengths. Personal time, for Lewis, is non-fundamental: it is reducible to facts about external time, causation, and change.

Here is Theodore Sider's helpful gloss:

Personal time is time experienced by the time traveler, whereas external time is time *simpliciter*, time according to the public ordering of events. . . personal time, as construed by Lewis anyway, is not an additional fundamental physical element of the world, but is rather a defined quantity. Roughly, experiencing one minute of personal time is defined as undergoing the amount of change that would normally occur to a person during one minute of external time (2001: 106).

It is worth adding that, at least in the case of ordinary objects such as persons, the change in question needs to be underpinned by causation. Lewis writes that “the properties of each stage depend causally on those of the stages just before in personal time, the dependence being such as tends to keep things the same” (1986b: 72).

At first, some may be tempted identify personal time with proper time and, more specifically, to identify personal time length properties with proper time length properties. After all, Lewis's initial characterization of a time traveler's personal time is “roughly, that which is measured by his wristwatch” (1986b: 69), and very similar language is typically used in informal characterizations relativistic proper time.<sup>8</sup>

Such an identification is clearly mistaken. First, proper time lengths are highly fundamental; they are the most fundamental temporal length properties. Personal time lengths are much less fundamental. Second, the possibility of Lewisian time travel would generate cases that block any proposed identification of a property from one of those families with a property from the other.

Consider the property having a personal time length of 25 years. This property cannot be identified with having a proper time length of 25 years – not, anyway, if Lewisian time travel is possible. Given that possibility, a person's personal time could fall out of step with the proper time elapsed along his path (and hence out of step with external time). This would happen if, e.g.,

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<sup>8</sup> For example, in their standard introductory textbook on special relativity, Edwin Taylor and John Archibald Wheeler write that “the length of a worldline between an initial and a final event is the elapsed time measured on a clock carried along the worldline between the two events. This is called the proper time, wristwatch time, or aging along this worldline” (1992: 162).

a person's behavior and all of his life-processes were 'slowed down' relative to his immediate surroundings, so that it took him (and his organs and cells, etc.) two hours to do what a normal person would do in one hour. Suppose that such a person is born in the year 2000, dies in the year 2050 (with the appearance of a normal 25-year-old), and never undergoes any unusual accelerations. Then his career has the property having a personal time length of 25 years, but it does not have the property having a proper time length of 25 years. (Its proper time length is roughly 50 years.) So the properties in question cannot be identified. Generalizing the argument in an obvious way, we can conclude that if Lewisian time travel is possible, then no personal time length property is the same as any proper time length property.

### 5.2 *The careers of Adam and Abel have incompatible fundamental temporal lengths*

I claimed that the *Abel's* career is one billion years long 'in the fundamental way', and Eagle agrees. What we disagree about is my claim that *Adam's* career is *two* billion years long in that same 'fundamental way'. By considering two series of cases, we should now be able to see that Eagle is right about Abel but wrong about Adam. We can begin with the *Atom Series*.

**Atom Case 1.** A lone hydrogen atom drifts in deep interstellar space; its path has a beginning and an end, and the proper time elapsed along that path is two billion years. The spacetime the atom inhabits is relativistic but cosmic time is definable in it. The atom's proper time never falls out of step with cosmic time.

**Atom Case 2.** This is like the previous case, but the atom inhabits a Gödel spacetime. As such, the spacetime contains no maximal spacelike hypersurfaces (it cannot be foliated into 'global time-slices') and, *a fortiori*, cosmic time cannot be defined in it. Nevertheless, the atom's two-billion-year-long path has a beginning and an end. Intrinsically, the atom's career is very much as it was in the previous case.

**Atom Case 3.** This is like the previous case, but the atom does not merely 'drift'. It accelerates in such a way that its path forms an *almost closed* timelike curve. The atom is created

in a lab and kept there for three years before being sent on its journey. Near the end of the journey, the (quite old) atom returns to the lab, no worse for the wear, just as the physicists are creating its 'younger self'. It spends the final three years of its career in the same room with its younger self, but the 'two' never chemically bond. Eventually the atom is destroyed. As in the previous cases, its path has a beginning and an end, and the proper time elapsed along that path is two billion years.

**Atom Case 4.** This is like the previous case, but in this case the atom's path forms a genuinely closed timelike curve, and the atom is never created or destroyed: its career has neither a beginning nor an end. Moreover, the atom never in any intuitive sense 'coexists with another version of itself': unlike in Atom Case 3, there are no smallish, locally spacelike regions that the atom's path intersects in two different places. Rather, the path is just a loop with a fairly simple shape. Again, the proper time elapsed along the path is two billion years.

**Atom Case 5.** This is like the previous case, but the atom's path forms a loop with a more complicated shape: it is doubled up like the edge of a Möbius strip. But in this case (unlike the Adam-Abel Case), the atom is never chemically bonded to itself; instead, it always at least 100 yards away from itself (as measured by it). Again, the proper time elapsed along its path is two billion years.

**Atom Case 6.** This is like the previous case, but the atom is always chemically bonded to itself, forming a molecule of H<sub>2</sub>, as in the Adam and Abel Case. But whereas the Adam and Abel Case occurs in a cylindrical spacetime, which can be carved up into global time-slices (and which perhaps even allows for cosmic time), Atom Case 6 occurs in a Gödel spacetime. Again, the proper time elapsed along the atom's path is two billion years.

**Adam Case 7.** This case = the Adam and Abel Case.

Atom Case 1 involves a hydrogen atom whose career has the property having a proper time length of two billion years, a property that is as fundamental as temporal length properties get. But for each pair of adjacent cases in the series, if the earlier case involves such an atom, then

so does the later case. None of the differences between the adjacent cases are significant enough to block this ‘inductive step’. (I leave it to the reader to confirm this to his or her own satisfaction.) So the Adam and Abel Case contains such an atom – Adam, presumably.

Adam’s career, then, has the property having a (relativistic) proper time length of 2 billion years. Since, as I noted earlier, this property is not the same property as having a (Lewisian) personal time length of 2 billion years, Eagle is just wrong when he says that “the only sense in which Adam has a two-billion-year-long career is in terms of its atomic personal time”. Indeed, the proper time length property that I am attributing to Adam’s career belongs to the most fundamental family of temporal length properties.

Eagle and I agree that Abel’s career is just one billion years long ‘in the fundamental way.’ But in case anyone is tempted to reject this claim, it can be supported by an argument parallel to the one just given. Consider the *Molecule Series*.

**Molecule Case 1.** Two hydrogen atoms drift together in deep interstellar space. Each of them has its own continuous path with a beginning and an end, and the proper time elapsed along each of the two paths is one billion years. The atoms are chemically bonded to each other throughout their respective careers, thus forming a molecule of H<sub>2</sub>. The spacetime they inhabit is relativistic, but cosmic time is definable in it. Neither of the atoms’ proper time ever falls out of step with cosmic time.

**Molecule Case 2.** This is like the previous case, but the atoms inhabit a Gödel spacetime. Again, the path of each atom has a beginning and an end and the proper time elapsed along it is one billion years.

**Molecule Case 3.** This is like the previous case, but the molecule of H<sub>2</sub> doesn’t merely ‘drift’; it accelerates and follows an almost closed timelike curve, so that it manages to spend some time in the same room with its younger self before it (along with its constituent atoms) pops out of existence. But as before, each of the atoms has a path with a beginning and an end and a proper time length of one billion years.

**Molecule Case 4.** This is like the previous case, but each of the two hydrogen atoms traces out its own closed timelike curve with a proper time length of one billion years. Neither atom is ever created or destroyed. Each of them has a career without a beginning or an end. Thus the molecule's path consists of two 'parallel' or 'side-by-side' loops that represent the paths of the molecule's constituent atoms.

**Molecule Case 5.** This is like the previous case, but instead of having two atoms each tracing out a simple loop of one billion years in proper time length, we have just one atom tracing out an edge-of-a-möbius-strip-like loop of two billion years in proper time length. By being bonded to 'another version of itself' throughout its career, this atom forms a molecule of H<sub>2</sub>. It would seem that main difference between this molecule and the one described in the previous case is that this one performs one additional (or one fewer) 180-degree rotation over the course of its (apparently one-billion-year-long) career. This case, like the previous case but unlike the Adam and Abel Case, occurs in a Gödel spacetime.

**Molecule Case 6.** This case = the Adam and Abel Case.

The argument now proceeds as before. Molecule Case 1 involves a molecule of H<sub>2</sub> whose career has the property having a proper time length of one billion years,<sup>9</sup> a property that is as fundamental as temporal length properties get. And for each pair of adjacent cases in the series, if the earlier case involves such a molecule, then so does the later case. Again, we don't seem to

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<sup>9</sup> One might deny this by appeal to the claim that, strictly speaking, the only entities that have (non-zero) proper time lengths are certain literally one-dimensional spacetime regions – viz., timelike curves. Of course, since Adam's career is not strictly one-dimensional either (hydrogen atoms are not spatially point-like), this would also disqualify Adam's career from having a proper time length. (1) If the careers of spatially extended objects do not have proper time lengths, this would leave it a mystery as to why (e.g.) synchronized spatially extended clocks fall out of step when one of them accelerates rapidly back and forth while the other one drifts inertially. True, it may be harder to assign a precise, determinate proper time length to a spatially extended career than to a one-dimensional timelike curve, but this hardly shows that the former entities do not have proper time lengths at all or that such entities never determinately differ with respect to their proper time lengths. On the contrary, sometimes they clearly do so differ, and indeed, if the arguments given in this section show anything, they show that Adam and Abel plausibly differ in just this way. (2) Moreover, even if one is willing to concede (which I am not) that only timelike curves have the *most* fundamental temporal length properties, there is still plenty of room to argue that there is another family of temporal length properties, the career-proper-time lengths, that can be possessed by spatially extended careers and that are sufficiently fundamental and sufficiently unlike mere personal time lengths as to put us under a fairly strong prima facie duty not to give a relativizing treatment of them.

have any differences between the cases that are significant enough to block this. So the Adam and Abel Case involves such a molecule – Abel, presumably.

Just as Adam’s career has the property having a proper time length of two billion years, Abel’s career has the property having a proper time length of one billion years. These properties are as fundamental as any temporal length properties, and they are incompatible with each other. So, contrary to Eagle, Adam’s career and Abel’s career do quite plausibly have incompatible fundamental temporal lengths. By Eagle’s lights, then, we cannot resist the argument for the non-identity of Adam and Abel without undermining the argument for temporary intrinsics.

## 6. Conclusion

I argued that if one identifies Adam and Abel (as a way of solving the type-C puzzle), then one must adopt a relativizing treatment of temporal lengths, and that, at least initially, this seems no better than adopting a relativizing treatment of shapes (as a way of resisting the argument from temporary intrinsics). Eagle tried to show that there is a significant disanalogy between the two cases: for the shapes that would need to be relativized are fundamental, whereas the only temporal lengths that would need to be relativized (personal time lengths) are highly non-fundamental.

Perhaps there really is significant disanalogy between the two cases lurking out there somewhere. I haven’t shown that there isn’t one. What I do take myself to have shown is that Eagle’s attempt to find such a disanalogy does not succeed. (Personal time lengths are not the only temporal lengths that would need to be relativized.) So far as his arguments are concerned, then, MC still holds.<sup>10</sup>

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