

Instantaneous Temporal Parts and Time Travel

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【Abstract】 The standard definition of an instantaneous temporal part cannot properly deal with cases involving time travel. This paper provides a new definition of an instantaneous temporal part by appealing to David Lewis's distinction between external time and personal time. The new definition avoids the problems because it does not allow more than one instantaneous temporal part of an object at each moment of its personal time. We argue that this new definition, combined with our new perdurantist semantic thesis, deals with cases of time travel successfully.

【Key Words】 instantaneous temporal part, time travel, personal time, perdurantist semantic thesis, David Lewis

1

Several philosophers have noted that the standard definition of an instantaneous temporal part cannot properly deal with cases involving time travel. In particular, it yields the wrong verdict about what counts and what does not count as an instantaneous temporal part when a time traveler visits himself. In this paper, we provide a new definition of an instantaneous temporal part by appealing to David Lewis's distinction between external time and personal time. We argue that this new definition deals with cases of time travel successfully.

2

The standard definition of an instantaneous temporal part comes from Sider (Sider 2001, p. 60), and it is the following:

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

It has been argued that this definition cannot handle cases such as the following (Effingham 2011, pp. 226-227):

Imagine that Marty is sitting at t_1 and t_2 , contemplating the time machine he has just built. At t_3 a man who looks just like Marty materializes out of thin air on the far side of the room. At t_4 Marty sits and wonders who this person is... At t_5 he shoots up with the realization that the person looking at him is

himself from the future. At t_6 Marty steps into his time machine, which teleports him to t_3 . Upon arriving in the past, Marty stands looking at his bemused self (at t_4) come to realize the situation (at t_5) and step into the time machine (at t_6).

This scenario can be depicted in the following figure:

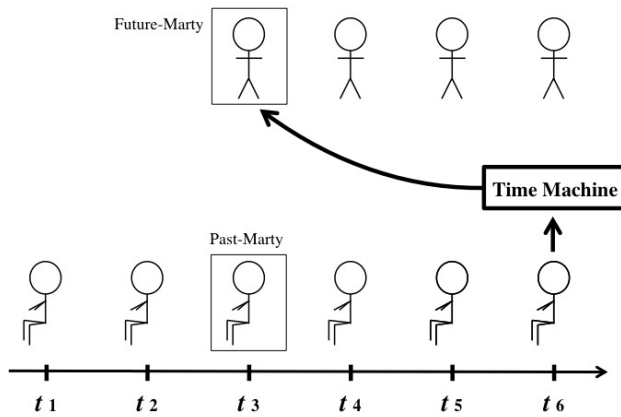


Fig 1. Marty and the Time Machine

* This diagram is a slightly modified version of Fig 1. in Effingham (2011).

This scenario raises problems for (1). The first problem is that according to (1), Past-Marty (the person-like temporal part of Marty at t_3 that is sitting) and Future-Marty (the person-like temporal part of Marty at t_3 that is standing) do not count as Marty's instantaneous temporal parts at t_3 . The reason is that neither of them satisfies (1)'s third conjunct. Past-Marty does not overlap any part of Future-Marty. But Future-Marty is a part of Marty that exists at t_3 . This means that Past-Marty does not overlap every part of Marty that exists at t_3 . Since Past-Marty

does not satisfy (iii) of (1), according to (1), Past-Marty is not an instantaneous temporal part of Marty at t_3 . The same is the case with Future-Marty. Future-Marty does not overlap every part of Marty that exists at t_3 , for Future-Marty does not overlap any part of Past-Marty, a part of Marty that exists at t_3 . Future-Marty does not satisfy the third conjunct of (1), so according to (1), Future-Marty is not an instantaneous temporal part of Marty at t_3 . However, we want to say that both Past-Marty and Future-Marty are two distinct instantaneous temporal parts of Marty at t_3 , one sitting, the other standing. This problem has been raised by Effingham (Effingham 2011, pp. 227-228), Miller (Miller 2006, pp. 312-313), and Sider (Sider 2001, p. 101).

The second problem is that according to (1), the fusion of Past-Marty and Future-Marty counts as an instantaneous temporal part of Marty at t_3 . The fusion of Past-Marty and Future-Marty is a part of Marty. The fusion of Past-Marty and Future-Marty exists at, but only at, time t_3 . The fusion of Past-Marty and Future-Marty overlaps every part of Marty that exists at t_3 . So the fusion of Past-Marty and Future-Marty satisfies all three conjuncts of (1), so according to (1), it is an instantaneous temporal part of Marty at t_3 (Effingham 2011, pp. 228-229).¹⁾ However, we do not want to say the fusion of Past-Marty and Future-Marty is an instantaneous temporal part of Marty at t_3 .

These problems lead to yet more problems for (1) when it is combined with the perdurantist semantic thesis. The perdurantist

¹⁾ This problem only arises if we assume that a fusion of Past-Marty and Future-Marty exists (Unrestricted Composition) and that the fusion is part of Marty (Strong Supplementation). In this paper, we assume both.

semantic thesis is the following (Effingham 2011, p. 226):

- (2) y is F at time t iff $\exists x$ such that (i) x is an instantaneous temporal part of y at time t ; (ii) x is F .

On one hand, we want to say that Marty is sitting at t_3 and that he is standing at t_3 in the above scenario. However, according to (1), neither Past-Marty nor Future-Marty count as instantaneous temporal parts of Marty at t_3 . Only the fusion of Past-Marty and Future-Marty counts as an instantaneous temporal part of Marty at t_3 . The fusion of Past-Marty and Future-Marty is neither sitting nor standing at t_3 . So according to (2), we can neither say that Marty is sitting at t_3 nor that he is standing at t_3 . On the other hand, we do not want to say that Marty has four hands and four legs at t_3 . However, since the fusion of Past-Marty and Future-Marty has four hands and four legs, according to (2), Marty has four hands and four legs at t_3 . But this is clearly false (Effingham 2011, pp. 227-229).

3

Effingham provides a modification of (1) on Sider's behalf (Effingham 2011, p. 229). We reformulate as follows:

- (3) x is an instantaneous temporal part of a person y at time t
 =_{df} (i) x is a part of y ; (ii) x exists at, but only at, time t ;
 (iii) x is person-like. (See Sider 2001, p. 101)

This definition counts Past-Marty and Future-Marty as

instantaneous temporal parts of Marty at t_3 , and it doesn't count the fusion of Past-Marty and Future-Marty as an instantaneous temporal part of Marty at t_3 . Miller adopts the definition similar to this one by distinguishing between maximal and non-maximal temporal parts (Miller 2006, pp. 312-313).

Effingham raises two problems for (3) (Effingham 2011, pp. 230-233). First, given that an instantaneous temporal part is not limited to persons, the definition should be amended to apply to other objects. However, it is unclear how to revise (3) in order to give a general definition. Second, (3) has the undesirable consequence that temporal parts of unborn children count as temporal parts of their mothers. An instantaneous temporal part of an unborn baby is person-like, it is a part of its mother and finally it exists only for an instant, satisfying all three conjuncts of (3). Rather than revising (3)—which may be possible but complicated—we explore a more promising approach below and offer a new definition.

4

Effingham provides his definition of an instantaneous temporal part as follows (Effingham 2011, p. 238):

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

Notice that the only difference between the standard definition (1) and Effingham's new definition (4) is that the latter does not

have the third conjunct. Effingham gives a reason why he deletes the third conjunct in his definition. He claims that perdurantists cannot accept both the definition of an instantaneous temporal part and the perdurantist semantic thesis. Given that perdurantists need the definition of an instantaneous temporal part, they should drop the perdurantist semantic thesis (2) (Effingham 2011, pp. 236-237). He then maintains that the third conjunct of (1) is “only introduced in light of endorsing (2).” (Effingham 2011, p. 237) He says (Effingham 2011, p. 237):

If you endorse (2) you need to ensure that instantaneous temporal parts are things like the (instantaneous) human sized and shaped chunks of my four-dimensional worm... This is so that the instantaneous temporal part that I have at this instant turns out to be 5' 11" so [given (2)] *I* get to be 5' 11" right now. Whereas, were (2) to be true, if an instantaneous chunk of my stomach turned out to be an instantaneous temporal part of me, I'd (erroneously) turn out to be stomach shaped right now. I believe this is the only work that (1)'s third conjunct is doing...

Effingham claims that once perdurantists drop (2), they do not need the third conjunct anymore.

However, Effingham's definition does not avoid all the original problems of (1). According to (4), the fusion of Past-Marty and Future-Marty still counts as an instantaneous temporal part of Marty at t_3 . Also, without (2), (4) does not have the desirable consequences that Marty is sitting at t_3 and that Marty is standing at t_3 .

Effingham might claim that the fact that his definition counts

the fusion of Past-Marty and Future-Marty as an instantaneous temporal part of Marty at t_3 is not a problem, for without (2), his definition does not have the undesirable consequence that Marty has four hands and four legs at t_3 . However, we still do not want the fusion of Past-Marty and Future-Marty to count as an instantaneous temporal part of Marty at t_3 , for it is not causally related to instantaneous temporal parts of Marty at other times in the right way. We think that the properties someone has now depend causally on the properties she had just before and that the properties she will have later depend causally on the properties she has now. We think that this causal dependence among her properties over time is what keeps her the same person over time. In the above scenario, the properties of Marty who arrives in the past at t_3 depend causally on the properties of Marty who steps into the time machine at t_6 . This is why we consider Marty who arrives in the past as the same person as Marty who steps into the time machine. On the right kind of causal dependence, Gilmore says (Gilmore 2016, pp. 2-3):

I might even discontinuously jump backward in time, disappearing at one time, t_2 , and reappearing 500 years earlier, at t_1 . If I have memories at time t_1 of what happens to me at t_2 , if my intrinsic properties at t_1 are typical of a person who was just in the overall intrinsic condition that I was in at t_2 , and if I am the way I am at t_1 largely *because* I am the way I am at t_2 , then...I count as having traveled backward in time.

Marty is the way he is when he arrives in the past at t_3 largely *because* he is the way he is when he steps into the time machine

at t_6 , and this makes Marty when he arrives in the past the same person as Marty who steps into the time machine. In terms of temporal parts, each instantaneous temporal part of someone has to be causally related to one another in the right way as depicted in Gilmore's passage (See also Lewis 1974, p. 148). Past-Marty is the way it is at t_3 largely *because* an instantaneous temporal part of Marty at t_2 is the way it is at t_2 , and Future-Marty is the way it is at t_3 largely *because* an instantaneous temporal part of Marty at t_6 is the way it is at t_6 .

But how about the fusion of Past-Marty and Future-Marty? Is the fusion the way it is at t_3 largely because an instantaneous temporal part of Marty at t_2 is the way it is at t_2 ? No. Are its intrinsic properties at t_3 typical of a person who was in the overall intrinsic condition that Marty was in at t_2 ? No. Is the fusion the way it is at t_3 largely because an instantaneous temporal part of Marty at t_6 is the way it is at t_6 ? No. Are its intrinsic properties at t_3 typical of a person who was in the overall intrinsic condition that Marty was in at t_6 ? No. The fusion of Past-Marty and Future-Marty is not causally related to Marty's instantaneous temporal parts in the right way. This gives us a reason not to want it to count as an instantaneous temporal part of Marty at t_3 .

Also, dropping the perdurantist semantic thesis is not a small cost for perdurantism. It is more desirable to provide a definition of an instantaneous temporal part that does not involve dropping the perdurantist semantic thesis.

We believe that it is possible to provide a new definition of an

instantaneous temporal part that does not require drastic measures such as deleting the third conjunct in (1) and giving up the perdurantist semantic thesis. This new definition of an instantaneous temporal part should satisfy the following desiderata:

- (I) The new definition keeps the third conjunct, albeit modified.
- (II) The new definition counts Past-Marty and Future-Marty as instantaneous temporal parts of Marty at t_3 .
- (III) The new definition does not count the fusion of Past-Marty and Future-Marty as an instantaneous temporal part of Marty at t_3 .
- (IV) Combined with (2) (or its slight modification), the new definition has the consequences that Marty is sitting at t_3 and that Marty is standing at t_3 .

Can there be a modification of (1) that achieves all of these? We provide one below.

5

Our idea is based on David Lewis's distinction between personal time and external time. Lewis introduces this distinction in the context of time travel (Lewis 1976). Someone's personal time is "roughly, that which is measured by his wristwatch" (Lewis 1976, p. 146) and external time is time itself. Lewis says (Lewis 1976, p. 146):

If you take the stages of a common person, they manifest certain regularities with respect to external time... Memories accumulate. Food digests. Hair grows. Wristwatch hands move. If you take the stages of a time traveler instead, they do not manifest the common regularities with respect to external time. But there is one way to assign coordinates to the time traveler's stages...so that the regularities that hold with respect to this assignment match those that commonly hold with respect to external time... Memories accumulate. Food digests. Hair grows. Wristwatch hands move. The assignment of coordinates that yields this match is the time traveler's personal time.

This shows that personal time is measured by a person's objective physical processes (See also Carroll 2011, p. 361 and Sider 2005, p. 330). The most elaborate account of personal time is provided by Gilmore. He says (Gilmore, 2016, p. 2):

According to Lewis, the personal time of an object *o* of kind *K* is an entity *T* such that the regularities in *o*'s career hold with respect to *T* in the same way that the regularities in the career of a typical member of kind *K* hold with respect to time itself. So, if I undergo the amount of change (in terms of cell division, telomere shortening, digestion, hair growth, heartbeats, accumulation of new memories and loss of old ones, etc.) that a human being would typically undergo in 2 h, and if the stages of those processes are causally related to one another in the right way, then 2 h of my personal time have elapsed for me, regardless of whether this occurs in 1 min, or 2 h, or 4 h of external time.

And then Gilmore assumes that "each personal time is a continuum of *moments*." (Gilmore 2016, p. 9)² His primitive predicate "x is a moment in the personal time of y" applies to

² He assumes that external time is a continuum of instants. (Gilmore 2016, p. 3)

“the salient relation that holds between moments and objects.” (Gilmore 2016, p. 9) Then, Gilmore defines an object’s personal time, as a whole, as “the set of moments-of-its-personal-time.” (Gilmore 2016, p. 9) Finally, he assume that “if m and m^* are moments and are connected by our ternary relation R [i.e., if m , m^* and some x instantiate R in some order],³⁾ then they are both moments in the personal time of some single object.” (Gilmore 2016, pp. 9-10 and n. 15)

There are a few things to note. First, although Lewis introduces personal time in the context of time travel, followed by many other philosophers, we can also talk about the personal time of someone who is not a time traveler.

Second, the concept of personal time is applicable to any physical object, not just persons (See Pruss 2013 and Sorensen 2005). For example, when a certain car has undergone the sort of change that normally occurs to the same kind of car during two minutes of external time, two minutes of its personal time has elapsed for it.

Third, and most importantly, although Lewis mentions “the stages of a common person” and Gilmore mentions “the stages of those processes,” this “stage” is not necessarily the perdurantists’ temporal part. Although endurantists do not accept the existence of temporal parts, they do use the concept of personal time to define time travel. For example, Keller and Nelson appeal to the concept of personal time when they argue for the possibility of

³⁾ Gilmore assumes that R is the “after a , b comes before c ” relation. (Gilmore 2016, p. 9)

time travel in a world where presentism is true. In particular, they claim that endurantists can accommodate the possibility of time travel where someone goes back to the past time and meets one's younger self by appealing to the distinction between external time and personal time (Keller and Nelson 2001, pp. 342-344). They even claim, "[a]n endurance theorist can usefully talk about temporal stages of a person's life without committing herself to the doctrine of temporal parts. She can usefully talk about someone's childhood, youth and old-age." (Keller and Nelson 2001, pp. 342) The point is that the concept of personal time must be understood in the way that is available both to perdurantists and endurantists.

The last point is important because if we appeal to the concept of personal time in defining an instantaneous temporal part, and if the concept of personal time is defined in terms of an instantaneous temporal part, our definition is circular. We have just argued that stages are not necessarily the perdurantists' temporal parts, and thus just because we mention "stages," it does not necessarily make our definition circular. However, one might still object as follows: If an object's personal time is understood as a way of ordering stages of a four-dimensional object and if these stages are material objects, then these stages must be temporal parts. But then, appealing to personal time in defining a temporal part is circular. In order to avoid this objection, we take personal time as a way of ordering stages of internal processes of the object, and thereby take these stages as physical or mental events.⁴⁾

Then, our view on personal time, based on Lewis' definition and borrowing many terms and assumptions from Gilmore's account, is as follows: we take the predicate "is a moment in the personal time of" as primitive. Each physical object has its own personal time. An object's personal time, as a whole, is the set of moments-of-its-personal-time. The order of these moments is based on the "a is before b" relation that holds among moments. Whether this relation holds among moments is based on (or grounded in) whether physical or mental events occurring within the object are causally related to one another in the right way.⁵⁾

4) It seems that Gilmore also takes stages as events whereas Lewis takes them as material objects.

5) One might still worry that stages of processes may be defined in terms of temporal parts of the career of an object, and if so, our definition is circular. To this, we reply that it is important to make a distinction between a definition of something and a theory about that thing (or even a rough characterization of that thing). For example, Gilmore defines the predicate "y is the personal time of object x" in terms of the primitive "is a moment in the personal time of." He then tries to spell out some of this primitive's interconnections with other notions, such as causation, stages of a career, temporal order, and so on. But this is only a rough characterization of the primitive, not the definition. Similarly, we officially take "is a moment in the personal time of" as primitive and we define an instantaneous temporal part in terms of this primitive. When we talk about "stages of processes" we only give a rough characterization of this primitive by spelling out how it is interconnected with other notions. Our primitive is not *defined* in terms of stages of processes. So even if stages of processes are defined in terms of temporal parts of the career of an object, our definition of an instantaneous temporal part is not circular. We owe this point to Cody Gilmore.

6

Let us introduce the expression “x exists (or is located) at some moment of its personal time, p” and stipulate its meaning as “x is in the state of having undergone a certain unit of change since some specific previous moment of its personal time.”⁶⁾ For example, when the specific previous moment of Tom’s personal time is his birth time, “Tom exists at age 20 of his personal time” is stipulated to mean that Tom is in the state of having undergone 20 years worth of change since his birth. Tom’s physical and mental events at that moment exhibit those features that are typical of a 20 year old man and are connected with his other physical and mental events in the right way. This is a purely technical stipulation and is not suggested as any kind of semantic thesis about these sentences or expressions such as “exists at” or “is located at.” However, this stipulation is not arbitrary. In our theory, the order of moments of someone’s personal time is based on the “a is before b” relation and whether this relation holds among moments of this person’s personal time is based on whether physical or mental events

⁶⁾ The expression’s meaning cannot be stipulated as “x is in the state of having undergone a certain unit of change since it came into existence.” It is conceivable that some physical object has an infinite past and never comes into existence. Also, in a world with circular time, some physical object has a circular career and thus never comes into existence. Both examples come from Gilmore (See Gilmore 2016, p. 26 for the first example and pp. 17-18 for the second example). For simplicity, we will ignore these examples and consider the birth time as the specific previous moment of its personal time below.

occurring within this person are causally related to one another in the right way. If someone undergoes the amount of physical and mental change that an ordinary person would typically undergo in 20 years, then 20 years of this person's personal time have elapsed for him. Then, ordinarily, from "Tom exists at age 20 of his personal time," it seems natural to assume that 20 years of Tom's personal time has elapsed for him since his birth, and from this it seems natural to infer that Tom is in the state of having undergone 20 years worth of change since his birth.

Now, by appealing to the personal time index as well as the external time index, we provide a new definition of an instantaneous temporal part.⁷⁾ For a moment of x 's personal time, let's use " p_x " and for a moment of y 's personal time, let's use " p_y ." Then, we get the following formulation where x exists at some instant of external time t and some moment of x 's personal time p_x , (t, p_x) , and y exists at some instant of external time t and some moment of y 's personal time p_y , (t, p_y) :

(1*) x is an instantaneous temporal part of y at $(t, p_y) =_{df} \exists p_x$ such that (i) x is a part of y that exists at (t, p_y) ; (ii) x exists at, but only at (t, p_x) ; (iii) x overlaps every part of y that exists at (t, p_y) .⁸⁾

7) Our proposal may be seen as a reversal of Lewis' view. While Lewis introduces personal time as a way of ordering temporal parts of a four-dimensional object, we use the ordering of moments of an object's personal time to identify its temporal parts.

8) Alternatively, it can be formulated as follows:

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

It is important to read “ x is a part of y that exists at (t, p_y) ” and “ x overlaps every part of y that exists at (t, p_y) ” as implying that it is only y , not x , that exists at (t, p_y) .⁹⁾ The only thing that exists at some moment of y ’s personal time p_y is y . Similarly, only x exists at some moment of x ’s personal time p_x . Given our stipulation that “ x exists at some moment of its personal time, p ” means that “ x is in the state of having undergone a certain unit of change since some specific previous moment of its personal time,” the statement that x exists at some moment of y ’s personal time p does not make sense.

For example, consider John and Tom. John is 40 years old and Tom is 10 years old. Consider “Tom exists at age 40 of John’s personal time.” What does this mean? Given our stipulation, this means, “Tom is in the state of having undergone 40 years worth of change since John’s birth.”¹⁰⁾ But this cannot be true. Tom is only 10 years old, so he cannot be in the state of having undergone 40 years worth of change since John’s birth. Given our stipulation, it does not make sense to say that Tom exists at (any moment of) John’s personal time.

Thus, in our view, an object cannot exist at (any moments of) any other object’s personal time.¹¹⁾ Since $x \neq y$ above, x cannot

⁹⁾ Therefore, “ x is an instantaneous temporal part of y at (t, p_y) ” does not imply that x exists at (t, p_y) . It is only y that exists at (t, p_y) .

¹⁰⁾ See n. 6 above.

¹¹⁾ Gilmore assumes, “if m and m^* are moments and are connected by our ternary relation R , then they are both moments in the personal time of some *single* object.” (Gilmore 2016, pp. 9-10; my italic) While this statement may seem similar to our claim that an object cannot exist at any other object’s personal time, we think that the two are different. For one can accept

exist at y 's personal time and y cannot exist at x 's personal time. Any instantaneous temporal parts of an object o cannot exist at o 's personal time. This also applies to any (spatial) proper parts of the object. Since my hand \neq me, my hand exists at my hand's personal time and I exist at my personal time. My hand cannot exist at my personal time.

One might object to us that this has an absurd consequence. I have my hand at some moment of my personal time p . However, if my hand does not exist at the same as I do, how can I have my hand at p ? It seems that if we assume that my hand does not exist at the same personal time as I do, we are forced to say that I do not have my hand at some moment of my personal time p . To this, we reply that in order for me to have my hand at some moment of my personal time p , all that is required is that my hand and I exist at the same *external* time. Even if my hand does not exist at the same personal time as I do, as long as both exist at the same external time, I do have my hand at some moment of my personal time p . The same is the case with temporal parts. I have a temporal part at some moment of my personal time p . If a temporal part of me does not exist at the same personal time as I do, how can I have my temporal part at p ? Again, in order for me to have a temporal part at some moment of my personal time p , all that is required is that a temporal part of me and I exist at the same *external* time.¹²⁾

Gilmore's assumption but still maintain the view that when $x \neq y$, x 's personal time can apply to (be assigned to) y 's personal time. Gilmore is not explicit on whether x 's personal time can apply to (be assigned to) y 's personal time, when $x \neq y$.

When $x \neq y$, x exists at x 's personal time and y exists at y 's personal time and x cannot exist at y 's personal time and y cannot exist at x 's personal time. So they cannot exist at the same personal time. However, they can exist at the same external time t . Without existing at (t, p_y) , x can be a (spatial or temporal) part of y that exists at (t, p_y) , for x and y can exist at the same external time t .¹³⁾

According to our new definition (1*), the moment of Marty's personal time at which Past-Marty is an instantaneous temporal part of Marty is different from the moment of Marty's personal time at which Future-Marty is an instantaneous temporal part of Marty. And there is no moment of Marty's personal time at which the fusion of Past-Marty and Future-Marty is an instantaneous temporal part of Marty. Thus, we are able to avoid the original problems of (1).¹⁴⁾

7

The strategy to appeal to the distinction between external time

¹²⁾ So we disagree with Lewis when he claims, “[w]e may assign locations in the time traveler’s personal time not only to his stages themselves but also to the events that go on around him.” (Lewis 1976, p. 146)

¹³⁾ A similar thing can be said about two temporal parts. How can Past-Marty and Future-Marty meet with each other if they do not exist at the same personal time? In order for them to meet with each other, all that is required is that they both exist at the same external time. In the above scenario, they both exist at the same external time t_3 . Similarly, John can meet Tom because they can exist at the same external time even if they do not exist at the same personal time.

¹⁴⁾ We will give more detailed accounts below.

and personal time is not a new strategy in philosophy of time. This strategy has been employed by endurantists in solving the problem of one and the same thing's wholly existing at two different places at the same time (Carroll's "the self-visitation paradox") (Carroll 2011, p. 359). For example, Keller and Nelson use this strategy (Keller and Nelson 2001) and Carroll explores adoption of this strategy in solving the self-visitation paradox on behalf of endurantists (Carroll 2011) (See also Bernstein 2015 and Pruss 2013).

Consider our original scenario. At external time t_3 , both Past-Marty and Future-Marty exist. This leads to a problem for endurantists because Marty is both sitting and standing at t_3 , that is, one and the same person has incompatible properties at the same time. In order to avoid this, endurantists appeal to the distinction between personal time and external time. This results in the following figure:

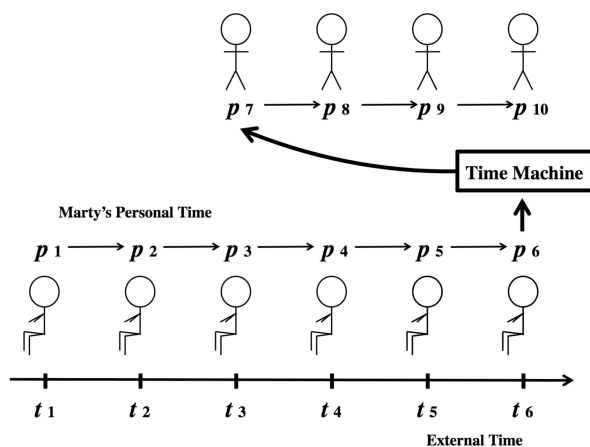


Fig 2. External time and Marty's Personal Time: Endurantism

According to this figure, p_3 and p_7 are different moments of Marty's personal time. Marty is sitting at p_3 , whereas Marty is standing at p_7 . And sitting at p_3 and standing at p_7 are properties that are compatible with each other. So it seems that endurantists do not have the consequence that one and the same person has incompatible properties at the same time.

However, there is an objection to them.¹⁵⁾ According to the objection, personal time also applies to those events that go around Marty.¹⁶⁾ At p_3 , among events that go around Marty that is sitting is the event that Marty is standing. So endurantists have to say that at p_3 , Marty, one and the same person, is sitting and standing at p_3 . The same applies to p_7 . At p_7 , Marty, one and the same person, is standing and sitting. We are back to the situation where one and the same person has incompatible properties at the same time.

One might think that our definition faces a similar problem. For the same reasoning seems to lead us to accept that Past-Marty and Future-Marty both exist at p_3 and at p_7 . And if so, then the fusion of Past-Marty and Future-Marty may count as an instantaneous temporal part of Marty at (t_3, p_3) and at (t_3, p_7) . However, this problem does not arise for our definition. We have already said that an object cannot exist at any other object's personal time. Since $\text{Past-Marty} \neq \text{Future-Marty}$, Past-Marty and

¹⁵⁾ See Carroll 2011, pp. 363-364.

¹⁶⁾ Carroll bases this objection on Lewis' claim. Lewis says, "[w]e may assign locations in the time traveler's personal time not only to his stages themselves but also to the events that go on around him." (Lewis 1976, p. 146) We disagree with Lewis on this point. See n. 12 above.

Future-Marty cannot exist at the same personal time.

One might still object. Even if the personal time of an object cannot apply to other objects, p_3 and p_7 apply both to Marty that is sitting and Marty that is standing, for Marty that is sitting at p_3 =Marty that is standing at p_7 and p_3 and p_7 are moments of Marty's personal time. Then, at p_3 , both Marty (that is sitting) and Marty (that is standing) exist. Also, at p_7 , both Marty (that is standing) and Marty (that is sitting) exist. Then, the fusion of Past-Marty and Future-Marty would count as an instantaneous temporal part of Marty at (t_3, p_3) by being a part of Marty that exists at (t_3, p_3) and overlapping every part of Marty that exists at (t_3, p_3) . Also, the fusion of Past-Marty and Future-Marty would count as an instantaneous temporal part of Marty at (t_3, p_7) by being a part of Marty that exists at (t_3, p_7) and overlapping every part of Marty that exists at (t_3, p_7) .

This problem does not arise for us. Let's suppose that p_3 is age 10 and p_7 is age 40. Given our stipulation, "Marty exists at p_3 " means that Marty is in the state of having undergone 10 years worth of change since his birth and "Marty exists at p_7 " means that Marty is in the state of having undergone 40 years worth of change since his birth.¹⁷⁾ 10 year old Marty cannot be in the state of having undergone 40 years worth of change since his birth and 40 year old Marty cannot be in the state of having undergone 10 years worth of change since his birth. This means that Marty that exists at p_3 cannot be 40 years old and Marty that exists at p_7 cannot be 10 years old. Marty that is sitting and

¹⁷⁾ See n. 6 above.

Marty that is standing cannot exist at the same personal time.¹⁸⁾

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Above, we have provided the following new definition of an instantaneous temporal part:

(1*) x is an instantaneous temporal part of y at $(t, p_y) =_{df} \exists p_x$ such that (i) x is a part of y that exists at (t, p_y) ; (ii) x exists at, but only at (t, p_x) ; (iii) x overlaps every part of y that exists at (t, p_y) .

Now, let us apply our definition to the original scenario. Then, we have the following figure:

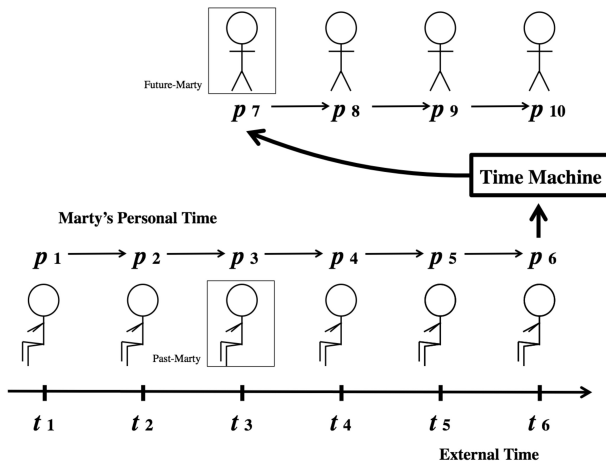


Fig 3. External time and Marty's Personal Time: Perdurantism

¹⁸⁾ We think that Carroll's objection to endurantism can be avoided in a similar way.

Let us see whether this new definition achieves all of the above four desiderata. The first one is:

(I) The new definition keeps the third conjunct, albeit modified.

This is easily met, for (1*) has the first and the third conjuncts with minor modifications due to the introduction of the personal time index.

The second desideratum is this:

(II) The new definition counts Past-Marty and Future-Marty as instantaneous temporal parts of Marty at t_3 .

To see whether (II) is met with our new definition, let us introduce the following:

(A) x is an instantaneous temporal part of y at t iff $\exists p_y$ such that x is an instantaneous temporal part of y at (t, p_y) .

Past-Marty is a part of Marty that exists at (t_3, p_3) , thereby satisfying the first conjunct of (1*). Past-Marty exists at, but only at (t_3, p_x) for some p_x , thereby satisfying the second conjunct of (1*). Finally, Past-Marty overlaps every part of Marty that exists at (t_3, p_3) , thereby satisfying the third conjunct of (1*). So Past-Marty is an instantaneous temporal part of Marty at (t_3, p_3) . Past-Marty is an instantaneous temporal part of Marty at t_3 and some moment of y 's personal time, namely, p_3 , so according to

(A), Past-Marty is an instantaneous temporal part of Marty at t_3 .

Future-Marty is a part of Marty that exists at (t_3, p_7) , thereby satisfying the first conjunct of (1*). Future-Marty exists at, but only at (t_3, p_x) for some p_x , thereby satisfying the second conjunct of (1*). And finally Future-Marty overlaps every part of Marty that exists at (t_3, p_7) , thereby satisfying the third conjunct of (1*). So Future-Marty is an instantaneous temporal part of Marty at (t_3, p_7) . Future-Marty is an instantaneous temporal part of Marty at t_3 and some moment of y 's personal time, namely, p_7 , so according to (A), Future-Marty is an instantaneous temporal part of Marty at t_3 . (II) is met.

The third desideratum is this:

(III) The new definition does not count the fusion of Past-Marty and Future-Marty as an instantaneous temporal part of Marty at t_3 .

This is also met. The fusion of Past-Marty and Future-Marty is not a part of Marty that exists at (t_3, p_3) , for the fusion of Past-Marty and Future-Marty is larger than (10 year old) Marty that exists at (t_3, p_3) .¹⁹⁾ So the fusion of Past-Marty and Future-Marty does not satisfy the first conjunct of (1*) at (t_3, p_3) . Similarly, the fusion of Past-Marty and Future-Marty is not a part of Marty that exists at (t_3, p_7) , for the fusion of Past-Marty and Future-Marty is larger than (40 year old) Marty that exists at (t_3, p_7) . So the fusion of Past-Marty and Future-Marty does not

¹⁹⁾ Let's suppose again that p_3 is age 10 and p_7 is age 40.

satisfy the first conjunct of (1*) at (t_3, p_7) . Since there are no moments of Marty's personal time p_y such that the fusion of Past-Marty and Future-Marty is an instantaneous temporal part of Marty at (t_3, p_y) , according to (A), the fusion of Past-Marty and Future-Marty is not an instantaneous temporal part of Marty at t_3 .

The fourth desideratum is this:

- (IV) Combined with (2) (or its slight modification), the new definition has the consequences that Marty is sitting at t_3 and that Marty is standing at t_3 .

Given (1*), (2) needs to be modified by incorporating the personal time index. We modify (2) as follows:

- (2*) y is F at (t, p_y) iff $\exists x$ such that (i) x is an instantaneous temporal part of y at (t, p_y) ; (ii) x is F .

(1*), combined with (2*), implies that Marty is sitting at (t_3, p_3) , for Past-Marty is an instantaneous temporal part of Marty at (t_3, p_3) and is sitting. It also implies that Marty is standing at (t_3, p_7) , for Future-Marty is an instantaneous temporal part of Marty at (t_3, p_7) and is standing. Now, to see whether (IV) is met with our new definition, we introduce the following:

- (B) y is F at t iff $\exists x \exists p_y$ such that (i) x is an instantaneous temporal part of y at (t, p_y) ; (ii) x is F .

In our original scenario, Marty is sitting at t_3 , for Past-Marty is an instantaneous temporal part of Marty at t_3 and some moment of Marty's personal time, namely, p_3 and is sitting. Marty is standing at t_3 , for Future-Marty is an instantaneous temporal part of Marty at t_3 and some moment of Marty's personal time, namely, p_7 and is standing. So the desideratum (IV) is achieved.

Also, (1*), combined with (2**), does not imply that Marty has four hands and four legs at t_3 , for the fusion of Past-Marty and Future-Marty is not an instantaneous temporal part of Marty at t_3 and any moment of Marty's personal time p . In fact, (1*), combined with (2*), does not imply that Marty has four hands and four legs at any t , for the fusion of Past-Marty and Future-Marty is not an instantaneous temporal part of Marty at any t and any p .

This completes our argument that the new definition of an instantaneous temporal part (1*) and the new perdurantist semantic thesis (2*) avoid all aforementioned problems and meet all of the desiderata.²⁰⁾

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순간의 시간적 부분과 시간여행

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순간의 시간적 부분에 대한 표준적 정의는 시간여행의 경우를 제대로 다루지 못하는 문제가 있다. 이 논문에서 우리는 데이빗 루이스의 외적 시간과 개인적 시간의 구분을 이용하여 순간의 시간적 부분에 대한 새로운 정의를 제시한다. 우리가 새롭게 제시하는 이 정의는 표준적인 정의와 같은 문제를 갖지 않는데, 우리의 정의에 의하면, 한 대상은 각각의 그 개인적 시간 각각의 순간에 두 개 이상의 순간의 시간적 부분을 가지지 않기 때문이다. 이 새로운 정의는 역시 우리가 새롭게 제시하는 perdurantist 의미론과 결합하여 시간여행의 경우를 성공적으로 다룬다.

주요어: 순간의 시간적 부분, 시간여행, 개인적 시간, perdurantist 의미론, 데이빗 루이스