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Presentists can believe in closed timelike curves

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Presentists believe that only presently existing things exist. In a Newtonian framework of three spatial dimensions, for example, presentists would say that all that exists is a three-dimensional spatial manifold, and the events in that manifold change with time. Eternalists, by contrast, believe that past, present, and future things all exist. In the Newtonian framework, eternalists believe in a four-dimensional space-time manifold, where events are scattered throughout this four-dimensional 'block universe'.

It is often thought that presentism is incompatible with time travel. William Godfrey-Smith (1980: 72), for example, says that 'the metaphysical picture which underlies time travel talk is that of the block universe.' In an informal survey of philosophers, the predominant answer to my question 'Is presentism compatible with time travel?' was 'No'. Simon Keller and Michael Nelson (2001: 334) also report that this is the common view. I will argue that this common view is incorrect. Specifically, I will argue that presentism is compatible with some stories that involve closed timelike curves, and that some of these stories are time-travel stories.¹

A closed timelike curve is a special case of a causal loop. A causal loop exists when there is a causal chain such that event A causes event B, event B causes event ... , where the chain eventually links back to event A. *Prima facie*, at least, causal loops are compatible with presentism: just have all the events in the loop occur at the same time. A timelike causal connection

¹ Keller and Nelson also argue that presentism is compatible with time travel, but their argument only works for time-travel stories that do *not* involve closed timelike curves. They write:

It may be that there are other sorts of stories which can be correctly regarded as time-travel stories and which are not compatible with presentism. ... We have in mind those time-travel stories that make essential reference to closed loops ... in space-time. Nothing we say will suggest that *these* stories are compatible with presentism. (2001: 334)

between events A and B occurs when A causes B and A temporally precedes B.² A timelike curve in space-time is a world-line in space-time that represents an object persisting in the forward direction through time, via timelike causal connections between the object at various times (or the temporal parts of the object). A timelike curve that forms a causal loop is a closed timelike curve.

Suppose for the moment that eternalism is true. In standard Newtonian space-time there cannot be closed timelike curves: any object persisting in the forward direction through time moves further and further in time away from its starting point. In *rolled-up space-time*, though, there can be closed timelike curves. Mathematically, rolled-up space-time can be produced by identifying points in Newtonian space-time: for all integers n , points (t, x, y, z) are identified with points $(t + nt_0, x, y, z)$, where t_0 is a constant. (Two-dimensional rolled-up space-time is isomorphic to the surface of an infinitely long cylinder, with the spatial dimension parallel to the axis of the cylinder.) In rolled-up space-time, an object persisting in the forward direction through time can come back to its spatio-temporal starting point, producing a closed timelike curve.

I see no logical problems with this characterization of rolled-up space-time, so I conclude that closed timelike curves are possible given eternalism. I will now show that they are possible given presentism.

Suppose that presentism is true, and consider a world where the phenomena are such that there are an infinite number of temporal epochs that are qualitatively identical. The phenomena are compatible with the world being one of rolled-up space-time, but the phenomena are also compatible with the world being one of eternal recurrence, where the various epochs are *only* qualitatively identical, not numerically identical. Presentists are faced with the question: is there some metaphysical fact of the matter that establishes whether this world is one of rolled-up space-time or eternal recurrence? Eternalists can appeal to the existing four-dimensional space-time structure to answer this question, but presentists deny the existence of four-dimensional space-time. Nevertheless, presentists can answer the question in the affirmative; presentists have metaphysical resources to establish that the world is one of rolled-up space-time.

Most presentists believe that there are truthmakers for past- and future-tensed truths. But what are these truthmakers? The most popular answer is due to John Bigelow (1996); see also Keller 2003. Bigelow argues that

² In the context of special or general relativity, 'timelike causal connection' has a more precise definition, but I do not want my discussion to be dependent on any particular theory of space-time. For a formal treatment of causal connections between events in the context of relativity theory, see Earman 1995.

there are present intrinsic properties of the world on which all past- and future-tensed truths supervene. These present intrinsic properties can be such that the world is one of eternal recurrence, and (with slight modification to Bigelow's theory) can be such that the world is one of rolled-up space-time.

In a world of eternal recurrence, the present intrinsic properties would be truthmakers for truths like 'object O at present time t is qualitatively but not numerically identical to object O^* at time $t + t_0$ '. Thus, the present intrinsic properties would provide truthmakers for the truth that the world is one of eternal recurrence.

In a world of rolled-up space-time, one must be more careful. It is not enough for the present intrinsic properties to be truthmakers for all truths about times in the open intervals $(t - t_0, t)$ and $(t, t + t_0)$, where t is the present time. These truthmakers would be compatible with a world that has a beginning and an end, and exists for a time interval of $2t_0$. A world of rolled-up space-time does not have a beginning or end. So to have truthmakers for rolled-up space-time, one must have more than truthmakers for all truths about times in the intervals $(t - t_0, t)$ and $(t, t + t_0)$. One needs truthmakers for truths about what happens when one evolves forward in time by duration t_0 , and beyond. These truthmakers would specify, for example, that objects at time t are numerically identical to objects at time $t + t_0$. Postulating such truthmakers is compatible with the spirit of Bigelow's proposal. I conclude that there can be present intrinsic properties which establish that a presentist world is one of rolled-up space-time.

I have established that presentism is compatible with closed timelike curves.³ But can stories that involve closed timelike curves be viewed as time-travel stories? Consider a story about an object living in rolled-up space-time, where $t_0 = 10$ years. Suppose that the object follows a closed timelike curve, so that after 10 years the object comes back to its spatio-temporal starting point. Does this journey count as time travel?

The standard definition of time travel is due to David Lewis (1976: 68): an object time-travels iff the separation in time between departure and arrival does not equal the duration of the object's journey. According to Lewis's definition, any object in rolled-up space-time which has come back to the time of its departure is a time traveller, since the duration of the trip

³ But it is not compatible with *all* types of closed timelike curves. For example, presentism is not compatible with Gödel space-time (Gödel 1949). I conjecture that presentism is only compatible with worlds with closed timelike curves where the failure of chronology in the four-dimensional space-time representation of the world is non-intrinsic: in other words, where the space-time can result from making identifications in a space-time without closed timelike curves.

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(10 years) is unequal to the difference between the departure and arrival times (0 years).

So stories involving rolled-up space-time can be time-travel stories. It follows that presentism is compatible not only with closed timelike curves, but with time travel.⁴

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⁴ For helpful comments, thanks to an anonymous referee, Anja Jauernig, Simon Keller, Brian Kierland, Chad Mohler, and especially Jill North.

Sufficient absences

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Externalism about psychological kinds is the thesis that certain of a subject's mental states and events are dependent for their individuation on the subject's environment. The thesis opens up the possibility that a subject's mental state and event kinds might vary with variations in the subject's environment, even while her physical properties, including her functional properties and her physical history, all individually and non-intentionally described, remain constant. Hence psychological externalism opens up the possibility that physically indistinguishable subjects could nevertheless be distinguishable psychologically.