undermines any reason those who are present might have for believing they are present.[2]

The University of Sydney
Sydney, Australia 2006
dbm@mail.usyd.edu.au

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[2] Thanks to Michael Tooley, a long past discussion of these matters was the origin of this paper. More recently I am indebted to Peter Forrest, Huw Price and Kristie Miller for helpful discussion.

The twins' paradox and temporal passage

KRISTIE MILLER

In a recent paper in this journal, McCall and Lowe (2003) argue that an understanding of Special Relativity reveals that the A theorist's notion of temporal passage is consistent with the B theory of time. They arrive at this conclusion by considering the twins' paradox, where one of two twins (T) travels to Alpha Centauri and back and upon her return has aged 30 years, while her earth-bound twin (S) has aged 40 years.

The usual explanation of this differential ageing is in terms of Minkowski geometry. The twin who remains on earth travels a direct world-line between st_1 (the spatio-temporal location at which twin T departs) and st_3 (the spatio-temporal location at which T returns). Picture this line as the longest side of an isosceles triangle. In travelling out to

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Alpha Centauri and then back to earth, T travels along the route of the other two sides of the triangle. That is, she travels from st_1, out to st_2 and then back to st_3. In Minkowski geometry the sum of the lengths of the shortest two sides of a triangle add up to less than the length of the longest side. So twin T travels the shorter temporal length of the two and thus ages less.

Temporal length is a term McCall and Lowe use and which I will continue to use for ease of exposition. But it should be noted that there is nothing purely temporal about temporal length. Temporal length just corresponds to the length of an object's world-line. Thus when the object is a person it may correspond to what Lewis calls personal time, but this is not because of anything intrinsically time-like (Lewis 1976).

If we think of this route as the temporal coordinates of a four dimensional object, we can see why we might conclude that there is no genuine temporal passage. There is no object that is 'moving through' time any more than there would be an object 'moving through' space if we measured its spatial coordinates. McCall and Lowe maintain though, that three and four dimensionalist accounts of persistence are equivalent, and thus we can also think of the twins as three dimensional objects that 'move along' the temporal dimension. Each twin is like a little clock that measures passing time, and the twins age different amounts because they experience different rates of passage.

The idea is that the A concept of temporal passage is just the other side of the coin of the B concept of temporal length. Does this reconcile the A theoretic notion of temporal passage with the B theory of time? No. The B theorist is quite at liberty to adopt this as an account of temporal passage *as understood by the B theorist*. After all, the B theorist never denied that there was temporal passage in *some* sense of the term. She only denies that there is temporal passage as it is understood by the A theorist. Namely, she denies that temporal passage involves the movement of an objective 'present'. So a deflationary account of temporal passage such as that presented by McCall and Lowe is consistent with the B theory. But it is a very deflationary account. For there is temporal passage only in so far as some object is wholly present at different spatio-temporal locations. And there are different rates of temporal passage relative to different frames of reference just if for two three-dimensional objects x and y that exist at some spatio-temporal location st_1, x and y have aged by different amounts – have world-lines of different length – when considered at another spatio-temporal location st_2.

This is an account of temporal passage, but not temporal passage as it is understood by the A theorist. The A theorist holds that temporal passage is the phenomenon that issues from the movement of an objective present, such that a temporal location genuinely changes its intrinsic

properties from futurity, through presentness, to pastness. This change in intrinsic properties *just is* temporal passage. But McCall and Lowe's account does not require that there be any objective present. 'Now' may be a mere indexical. Nor does it require that there be any intrinsic properties of pastness and futurity.

For the A theorist, just as the rate of spatial passage is something over and above spatial length, so too the rate of temporal passage is something over and above temporal length. Consider the case where A and B travel to some destination C, and B takes a spatial short cut. We do not infer from the fact that B arrives earlier, that he travelled *faster*. Similarly, twin T effectively takes a 'temporal short cut', travelling a shorter temporal length to reach the same destination. If McCall and Lowe are right, then T's taking a temporal short cut *just is* T travelling at a slower temporal rate. But for the A theorist these are distinct issues. If there is a single objective moving present, then the rate of passage of both S and T will be the same, despite the fact that they travel different distances.

None of this is to contend that the A theory concept of temporal passage is coherent, only that it is not the concept used by McCall and Lowe. Of course, their account could be supplemented in various ways so that it would preserve more A intuitions. McCall's own branching universe model which allows for an objective present would allow for temporal passage as understood by the A theorist (McCall 1994). Supplementing the account in this manner, however, would leave it open to various criticisms, including the claim by B theorists that it is subject to a vicious regress of temporal dimensions in which to measure the temporal passage (Smart 1949, 1980; Nerlich 1998).

What this shows is that we can define up a notion of temporal passage that is consistent with the B theory, but this notion is not one that the A theorist would accept as genuine temporal passage. So we cannot, I am afraid, have our cake and eat it too.[1]

University of Queensland
Brisbane, Australia 4072
kristie_miller@yahoo.com

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[1] With thanks to David Braddon-Mitchell and Mark Colyvan for helpful discussion of these issues.

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Dispositions and the principle of least action

JOEL KATZAV

1. Introduction

My aim is to argue for the incompatibility of one of the central principles of physics, namely the *principle of least action* (PLA), with the increasingly popular view that the world is, ultimately, merely something like a conglomerate of objects and irreducible dispositions. First, I argue that the essentialist implications many suppose this view has are not compatible with the PLA. Second, I argue that, irrespective of whether this view has any essentialist implications, it is not compatible with the kind of explanation that the PLA affords.

2. Dispositionalism

Dispositional properties are, unlike categorical properties, here supposed to be properties that are not wholly manifest in the present. *Dispositionalism* is the view that the world is ultimately a conglomerate of objects and dispositions.[1,2] On this view, there is some level of true description of objects in the world that ascribes to them dispositions that are fundamental, that is to say that are not explicable in categorical terms. Moreover, change is said to consist in the manifestation of these dispositions in response to appropriate prompting. Dispositions are thus supposed to be the ultimate ontological units that explain events.[3]

[1] Supporters of dispositionalism include, among others, Harré and Madden (1975), Fetzer (1977), Shoemaker (1984), Cartwright (1989), Mumford (1998) and Ellis (2001).

[2] Some dispositionalists would also postulate processes along with their dispositions. Nothing will turn upon this here.

[3] Dispositionalism does not, by itself, preclude supposing that there are fundamental categorical properties and relations. For example, the dispositionalist may think of spatio-temporal relations in categorical terms.

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