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Is the relativity of simultaneity a temporal illusion?

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It is commonplace among ordinary folk to associate tense with language. However, which kinds of things can be tensed is a substantial question. Peter Ludlow puts the question as follows: 'Is tense, as some contend, merely a feature of language (linguistic tense) but not of thought or the world, or are thoughts and facts about the world tensed as well—tensed facts being examples of what we could call "metaphysical tense"?' (Ludlow 2012). Tensism, the view that the world itself is tensed, treats the distinction among past, present and future as mind-independent (Crisp 2003; Cappelen and Hawthorne 2009; Ludlow 2012; Zimmerman 2006).

Following McTaggart (1908), this view is also sometimes referred to as the 'A-view'. McTaggart contrasts this view with the B-view, according to which there is no real objective present, though there is still time in the sense that events in the B series are ordered by means of an irreflexive, transitive and asymmetric *earlier-than* relation.

If tensism is true, then the present moment has a special status that makes it objectively distinct from the past and the future. Temporal passage is not conceptually entailed by tensism; for example, it's a position in conceptual space that 11:23 pm, 15 January 2004 CST has a special (and permanent) status as the present moment but this position is clearly unrealistic and indefensible. So, it is fair to assume that tensism and temporal passage go hand in hand.

Presentism, the view that only present things exist, is by no means the only way to account for temporal passage. In fact, the claim that time passes has no direct bearing on the question of whether the past and the future exist (Callender 2012; Maudlin 2002), for there are other views that grant both temporal passage and the existence of the past and the future, including the moving spotlight view, the growing block view and a view that may simply AQ3 be called 'passage' (Brogaard 2012; Hawthorne and Cappelen 2009). On the moving spotlight view, the universe is a four-dimensional spacetime manifold that includes an objective and dynamic present. On the growing block view, the universe is a continuously expanding four-dimensional spacetime manifold whose expanding surface coincides with an objective present moment. On the passage view, the past and the future exist but only present events are happening (alternative: only present entities are concrete). Though there are various ways to lay out tensism, what unites the different positions is the thought that there is an objective, ever-changing 'now' that typically coincides with our phenomenal experiences of the present.

One of the main objections to tensism has been Einstein's argument from special relativity. Einstein concluded, on the basis of the observation that the

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speed of light is constant, that absolute simultaneity is a myth. Einstein defined simultaneity and clock synchronization in terms of observation of light rays (Einstein 1905). Suppose we want to figure out whether two events occurring at two points, *A* and *B*, are simultaneous. We first measure the distance between the two points, *A* and *B*. If an observer *M*, located at the mid-point between *A* and *B*, sees flashes at *A* and *B* as occurring at the same time, then the flashes are simultaneous, according to Einstein, because light would have taken the same time to travel to *M* from *A* and *B*.

Einstein's famous thought experiment demonstrating the relativity of simultaneity runs as follows (Einstein 1949). A stationary observer *M* on a platform sees two flashes occurring simultaneously at *A* and *B*, two points that are equidistant to the observer and which, at the time of emission, correspond with the beginning and endpoints of a moving train. However, an observer *M** located at the mid-point inside the train sees the light, which travels a emitted at *A* before the light emitted at *B* because she/he is travelling towards the light emitted at *A* and away from the light emitted at *B* (see Figure 1a and b). Though a similar phenomenon could be experienced with sound waves rather than light waves, the difference is that a moving observer would be able to deduce that the sounds occurred simultaneously by taking into account that a sound wave in a moving medium travels faster than a sound wave in a stationary medium. Since the speed of light is unaffected by the velocity of the medium, a moving observer cannot correctly make a similar deduction with respect to light. According to Einstein, simultaneity is relative to an inertial reference frame (i.e. a perspective in space that is not undergoing a change in motion); there is no privileged frame of reference.

However, there is some reason to question the assumption that there is no privileged frame of reference. According to Einstein, cause and effect must always be temporally separated: if two events stand in the relation of cause and effect, it should not be possible to transform them to simultaneity. Further, if one event causes a second, then this order of cause and effect is constant in all frames of reference (Einstein 1949, 1954; Tolman 1917). So the sequence of cause and effect is not relative but absolute. This is the *Einstein principle of causality*.

But suppose now that a flash emitted from a point *A* causes a flash to be emitted from a point *B*. If *A* and *B* are separated by two light-seconds, then an observer located at the midpoint between *A* and *B* will conclude that *B* occurred two seconds after *A*. A person on a train who is situated one light-second away from *A* when *A* occurs and who travels with a velocity of 0.5 light-seconds per second towards *B* will perceive *A* and *B* as occurring simultaneously after having been travelling for two seconds. Here the two observers do not agree on the sequence of cause and effect. One judges a cause–effect relationship, the other judges simultaneity (see Figure 2a and b). Simultaneous events cannot stand in a cause–effect relationship, according to Einstein. So, the moving observer is wrong in this case, as she/he fails to

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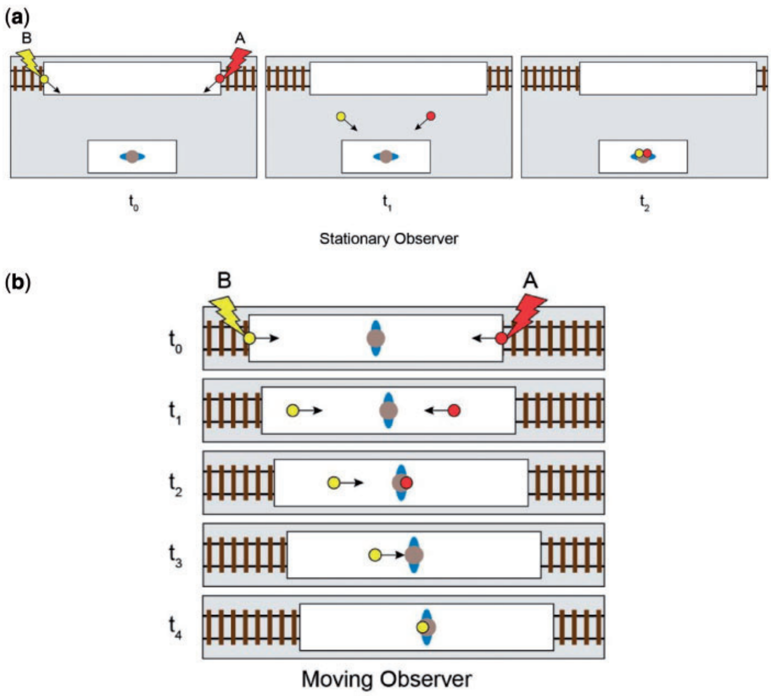

Figure 1. Einstein's famous train example. (**a**) When light is emitted from two distinct points equidistant to a stationary observer, the light arrives to the observer's location simultaneously. As a result, the observer judges that the flashes occurred simultaneously. (**b**) However, light travelling in the direction of the train must 'catch up' to the moving observer. Thus, the moving observer judges the light travelling in the direction of the train to have occurred after the light travelling opposite to the direction of the train.

observe the correct cause–effect sequence. It is open, then, to argue that the moving observer is also wrong in the original thought experiment. The moving observer, we might say, simply is subject to a temporal illusion, owing to her/his increased velocity relative to the observer on the platform. That is, given the analogy of the cases, we can postulate on reasonably good grounds that absolute simultaneity is to be defined with respect to rest frames of reference (extrapolated from real cases).

One might object to this argument that there are no rest frames of reference. In Galilean and Newtonian physics, Earth is stationary relative to the 'aether'. In his 1905 paper on the special theory of relativity, Einstein explicitly rejected not only the notion of an aether, but also the idea of a state of absolute rest for electromagnetic phenomena. So, it may seem far from innocuous to attempt a definition of absolute simultaneity relative to a rest frame.

This objection, however, begs the question. What Einstein meant when he claimed that there is no state of absolute rest was that there is no preferred

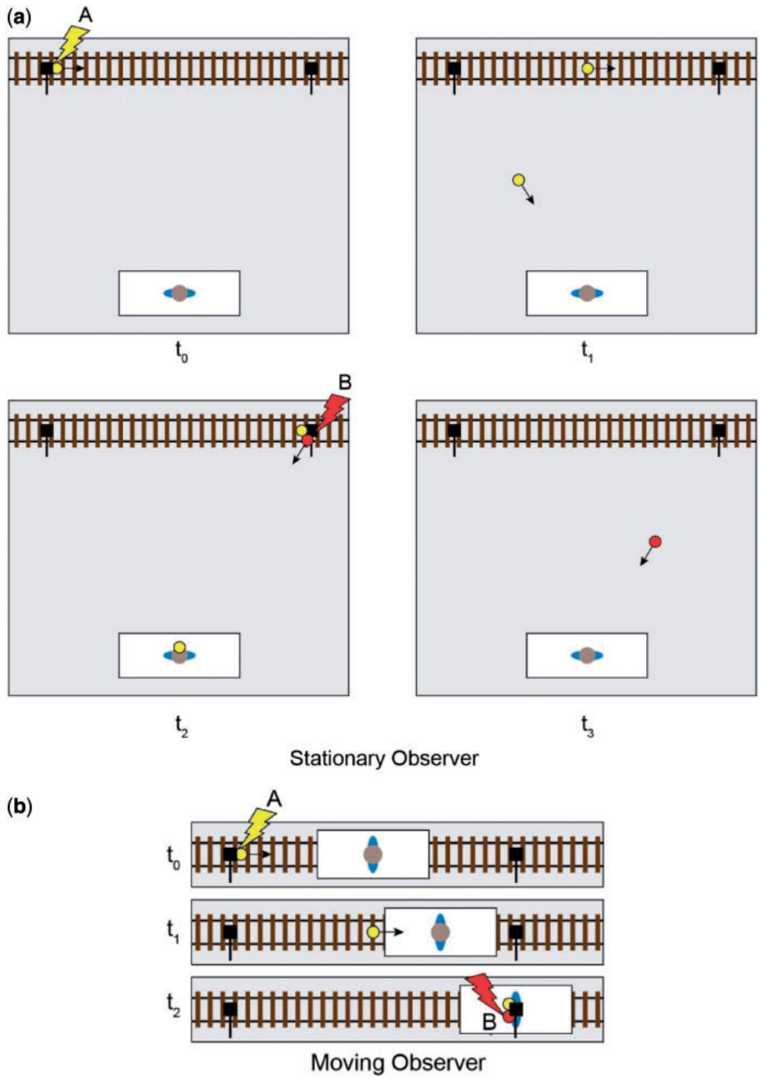

Figure 2. Flash causation. (**a**) Suppose light from an emitter *A* travelling in the direction of the train triggers an emitter *B* further along the train tracks. A stationary viewer would correctly judge that light from *A* is emitted before light from *B*. (**b**) However, because the light from both emitters would arrive simultaneously to the moving observer, the moving observer would incorrectly judge that the flashes occurred simultaneously.

inertial frame relative to which one can judge absolute rest. So, appealing to his claim that there is no state of absolute rest in order to counter the above argument presupposes the conclusion of his argument.

The idea of a rest frame is, indeed, central to Einstein's original derivation of the Lorentz transformation in his 1905 paper. The notion of an inertial

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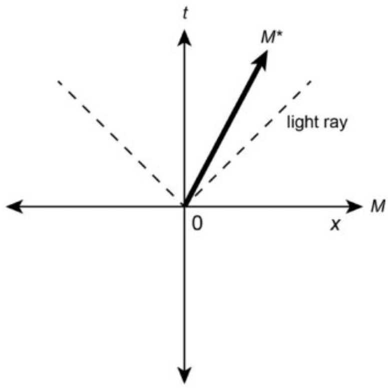

Figure 3. Lorentz transformation. Two individuals moving at different velocities may observe different distances, elapsed times or ordering of events. However, Einstein proved the Lorentz transformation by treating the $\{x, t\}$ coordinates as an absolute rest frame.

frame is mathematically described as a coordinate system in which the coordinate axes specify the rest frame (Einstein 1905) (see Figure 3).[1] The flashes of light are fully determined by the sets of coordinates $\{x, t\}$ and $\{x', t\}$ corresponding to the observers M and M^*, respectively. The clocks of M and M^* are located at fixed points in space and are synchronized at the origin $t = 0$, and $t' = 0$, etc. In fact, Einstein makes explicit that he is relying on the idea of a rest frame originating in Newtonian mechanics: 'Let us take a system of coordinates in which the equations of Newtonian mechanics hold good' (1905). Though Einstein rejected the notion of an aether (a Newtonian rest frame or absolute space) in the 1905 paper, he returned to it in 1916 in a letter to Lorentz, arguing that aether is required to avoid that movements take place with respect to empty space (Miller 1986: 55). Einstein's new aether was the curved spacetime of the general theory of relativity. Though Einstein claimed that the special theory is consistent with the new aether postulate, it is far from clear that he ever fully discarded the notion of absolute rest, except with respect to local phenomena.

Furthermore, while Einstein correctly noticed that experiments involving causally inert electromagnetic phenomena do not depend on the absolute motion of the laboratory, but only on the relative motion of components within the experiment, he didn't deny that one inertial frame outside of a laboratory may be a more natural candidate to be a rest frame compared to another. Einstein's acclaimed thought experiment rests on this very idea. And for good reasons: in the real world when dealing with causal phenomena there are objective measures for determining approximate rest versus motion, for example matching observations of cause and effect to the principles that

1 The word 'frame' was used as a translation of the German word for 'coordinate system'.

cause and effect are separated by a time-like interval and that the effect is future relative to its cause. So, for most inertial observers who disagree about the simultaneity of events merely because they are in different inertial frames, we can determine whose frame is closer to rest and hence determine who is approximately right and who is just plain wrong.

Here is another objection: in one of the often presented illustrations of simultaneity, two events *A* and *B* are simultaneous relative to an observer *M* located at the mid-point between *A* and *B*. As *M* sees *A* and *B* simultaneously, *A* and *B* are judged to be simultaneous because light would have taken the same time to travel to *M* from *A* and *B*. In the causal train scenario provided above, we don't have an observer who is located at the mid-point between two events and who can conclude that *A* and *B* are simultaneous on the basis of considerations pertaining to distance and the speed of light. So, it may be said, we can account for the temporal illusion of this case while retaining the non-illusory nature of the original case by pointing to the fact that *M* wasn't equidistant from the events in our presented scenario. The problem with this objection is that it would carry over (in reverse) to the moving train observer in Einstein's original thought experiment. Here the observer is equidistant from the two events, yet what matters for the truth of the lack-of-simultaneity judgement is the subject's observation that the events do not occur simultaneously.

If we do grant that simultaneity is absolute as defined relative to rest frames, then an important objection to tensism is undermined. There are still complex issues to consider pertaining to general relativity, which posits curved as opposed to flat spacetime, and quantum mechanics (Crisp 2003, 2007; Putnam 1967; Savitt 2000; Saunders 2002; Sider 2001). For all we have said here, general relativity and quantum mechanics provide strong objections to tensism. However, special relativity has been frequently cited as tensism's enemy, probably more than any other scientific theory (e.g. Baker 1974; Callender 2000; Crisp 2007; Godfrey-Smith 1979; Hinchliff 1996, 2000; Maxwell 1985; Rea 1998, 2003; Rietdijk 1966, 1976; AQ3 Savitt 1994; Sider 2001; Sklar 1974, 1981; Stein 1968, 1970, 1991). That enemy, we dare say, has been defeated.

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AQ2

Abstract

Tensism holds that the present moment has a special status that sets it apart from the past and the future, independently of perceivers. One of the main objections to this view has been Einstein's argument from special relativity, which aims at showing that absolute simultaneity is a myth. We argue that the moving observer in a causal variant of Einstein's original thought experiment is subject to a temporal illusion. Owing to the analogy of the cases, this casts doubt on the conjectures that there is no privileged frame of reference and that special relativity poses a problem for tensism.

Keywords: cause–effect sequence, rest frame, absolute simultaneity, presentism, special relativity, temporal illusion, temporal passage, tensism