

The relativity of simultaneity is not a temporal illusion

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B. Brogaard and K. Marlow (2013) have argued that the relativity of simultaneity of Einstein's Special Theory of Relativity (STR) may be a temporal illusion. The implication is that STR, as 'an enemy' of the A-Theory of Time, 'has been defeated' – as the last sentence of their article concludes. Their argument for the illusory character of the relativity of simultaneity is that in order to avoid a contradiction with Einstein's *principle of causality*, which says that the sequence of cause and effect is absolute, rather than relative, one has to admit there is a preferred frame of reference. (One could then identify the ontological present, which the A-Theory of Time arguably requires, with the set of simultaneous events in this preferred frame.) We show that Brogaard and Marlow have made an error in their argument, which makes their claim crumble.

Brogaard and Marlow consider the following thought experiment of 'flash causation', which is a variant of the one that Einstein considered in order to demonstrate that his Light Postulate of STR (the speed of light does not depend on the speed of the source) implies the relativity of simultaneity. An emitter *A*, on a moving train, sends a signal to an emitter *B* further along the train, which it triggers to send a light signal too upon arrival. Some stationary observer, in the embankment frame, judges that light is emitted by *A* *before* the light signal is emitted by *B*. When the emitters stand separated by 2 light-seconds, the observer judges that the light signal is emitted by *A* 2 seconds before *B* emits light. Then Brogaard and Marlow proceed as follows (2013: 638):

A person on a train who is situated 1 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 2 seconds. Here the two observes do not agree on the sequence of cause and effect. Simultaneous events cannot stand in a cause-effect relationship, according to Einstein. So, the moving observer is wrong in this case, as she fails to observe the correct cause-effect sequence. It is open, then, to argue that the moving observer is also wrong in the original thought experiment.

This observer on the moving train commits however an error of judgment. She confuses the emission event of the light signal by *A* and the arrival event of the emitted light signal at *B*. Source *B* sends a light signal simultaneously with the arrival of the light signal sent by *A*, but this arrival event, and thus

also the emission event by *B*, occurs 2 seconds later than the emission event by *A*. If she observes the arrival at *B* of the light signal emitted by *A*, and she knows the fixed distance between *A* and *B* (2 light-seconds), she can calculate *when* the light signal has been emitted by *A*, which is the time of the emission event at *A*, and that is (2 light-seconds divided by the speed of light equals) 2 seconds before the arrival event at *A*. Hence the two observers, the stationary one in the embankment frame and the moving one on the train, do not disagree but agree on the temporal ordering of the emission event by *A* and the arrival event at *B* (and hence the emission event at *B*). They even agree on how much earlier the emission event was, because the speed of light is the same in all frames of reference. There is no conflict with Einstein's principle of causality to be resolved. There is no need to admit a preferred frame of reference to uphold this principle of causality. The defence of the A-Theory of Time against STR fails.

Einstein's principle that the causal order of events is absolute seems incompatible with the relativity of the temporal order of events. This is however an intellectual illusion, to which Brogaard and Marlow have fallen prey: only *time-like* and *light-like* separated events can be causally connected, and only *space-like* separated events have a relative temporal order. There is no contradiction, because *these* are mutually exclusive cases.

Should we conclude that STR remains the enemy of the A-Theory of Time, as so many have argued? About 15 years ago, N. Rakic (1997) formally proved that if the theory of Minkowski space-time *without* an ontological present is consistent (i.e. STR), then the same theory *with* an ontological present is consistent too, which need not be defined by some simultaneity in any frame of reference. STR therefore is not the logical enemy of the A-Theory of Time. This is not to deny that it is a substantial *metaphysical* task to construct an A-Theory of Time that fits STR like a glove. But it is to affirm that there are no *logical* obstacles for achieving this task. Not all is lost for Brogaard and Marlow.

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