

Relativity and the A-Theory

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The Special Theory of Relativity (STR) is widely supposed to be in tension with theories of time which give a special significance to the present moment. In this chapter, I will develop and explore the prospects for resolution of this tension.

Overview. In §1 I will explain A-theories of time and introduce the key pieces of ideology on which they rely. In the following section (§2), I will introduce just enough of STR to enable us to bring that theory into contact with the A-theory. In §3, I will develop the tension between STR and the A-theory. In §4 I will consider A-theoretic responses that preserve the adequacy and completeness of STR; in §5 I will consider A-theoretic responses which accept STR, so far as it goes, but take it to be incomplete with respect to tensed facts. I conclude in §6 with my evaluation of the overall prospects for the A-theory in light of STR.

§1. The A-theory

A first argument. It is a mundane observation that not everything which happens had to happen. The actual concrete world might have been different in various ways, and if it had been, different things would have happened. But what is the case actually is what is the case *simpliciter* – it's just the way things **are** (rather than the way things are in, or according to, such-and-such a possibility). So the way things are is not the way they must necessarily be. In this sense, reality (the way things are) is contingent.

A second argument. It may seem equally mundane to observe that not everything which happens always happens. The actual concrete world was (and will be) different in various ways; and when it was (will be), different things were (will be) happening. But what is the case now is what is the case *simpliciter* – it's just the way things **are** (rather than the way things are at, or according to, such-and-such a time). So the way things are is not the way they are permanently. In this sense, reality (the way things are) is temporary.

It is important to be clear on how to understand the conclusion of this second argument. It claims that there is a basic distinction between the things which happen in reality – or **really happen** – and those which merely did or will happen. Moments of time differ from one another concerning what happens when they accurately represent reality, or **are present**. So what really happens genuinely changes over time as the character of present reality changes. Let us call the philosophers who endorse this conclusion, thus understood, **A-theorists** (following some rebarbative but entrenched terminology due to McTaggart 1908).

There are many different views that all agree on the A-theory, so characterised. One is **presentism**, the view that concrete reality is temporally unextended, but that this momentary reality changes its character as different times are successively present (Bourne 2006; Markosian 2004; Sider 2001). (Presentists disagree over the reality of other times, but all deny the existence of other times that are distinct parts of concrete reality.) Everything that happens, happens in the one existing present moment. However, since the character of present reality *was* different, and *will be* different, those events are not permanent happenings. Another view is the **moving spotlight**, the view that while reality is temporally extended, there is an objectively privileged moment such that everything which is happening according to that moment is really happening *simpliciter* (Cameron 2014; Deasy 2014). There is real change in reality, but unlike on the presentist view, there is no change in what things exist – rather, there is change in what is true *simpliciter* of what exists.

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The contrasting view, which we may call the **B-theory**, is that reality is not temporary. On this view, the correct way to understand phenomena of apparent temporariness, such as natural language tense, involves a temporally extended reality which exhibits internal

variation between its distinct parts, rather than change in the character of a momentary present. Every event in this temporally extended reality is real and thus really happens: the way things are is the way that temporal reality is *in toto*. There are no events of which it is true that they exist, while false that they are really happening. A description of reality which describes the global pattern of variation in happenings from time to time and place to place can be a complete and correct account of what is true *simpliciter*, even if it doesn't give any special role to what is true of the present moment.

B-theorists reject the second argument with which we began; yet almost all of them accept the first argument. At which point do those arguments diverge? A typical B-theorist might say: the claim from which the A-theory appears to follow – namely 'the way things are is not the way they are permanently' – does not in fact entail the A-theory. For *the way things are* contains a present tensed *are*. The B-theorist regards tense as a surface phenomenon of natural language sentences, not reflected in the underlying propositions those sentences express. Those propositions, say the B-theorist, have their truth values permanently. They will typically say that tensed phrases are **context-sensitive**: what *the way things are* expresses, when uttered at *t*, is something like THE WAY THINGS ARE AT *t*. According to the B-theorist, not every time is such that the way things are then is the way things are at *t*. So the B-theorist says: in every utterance of the second argument, the key claim 'the way things are is not the way they are permanently' expresses a truth. But the truth expressed is not one that entails the A-theory. The truth expressed is something like THE WAY THINGS ARE AT *t* IS NOT THE WAY THINGS ARE AT ALL TIMES. This is true because the B-theorist accepts variation from time to time in temporally extended reality. But to entail the A-theory, there would have to be a context-insensitive use of 'the way things are' on which it always means the same thing, namely, it denotes the totality of temporal reality. According to the B-theory, the premises in the second argument don't involve any such use – and if we were to stipulate that 'the way things are' is to be understood invariantly, the key premise would be false, since it would express something the B-theorist denies, namely, that the way things are *in toto* is not the way they are permanently.

There are many arguments, philosophical and linguistic, that aim to adjudicate this dispute between the A-theory and the B-theory. For example, one major discussion concerns precisely this issue of whether tensed language is best understood as involving context-

sensitivity (Partee 1973; King 2003; Lewis 1980; Brogaard 2012). This discussion embraces another issue, involving the apparent commitment of the A-theory to the idea that because reality changes over time, what is true concerning reality also changes over time, so that propositions vary in their truth value from time to time. This view, known as **propositional temporalism**, has proponents who think only temporal propositions can be the objects of our temporary propositional attitude ascriptions (Prior 1959); or that only temporal propositions can explain the non-redundancy of temporal operators like ‘it was the case that’ when applied to natural language sentences (Kaplan 1989). It has detractors who think that temporal propositions actually don’t successfully play the proposition role, e.g., in belief reports (Richard 1981).¹

In this chapter, I will focus on another line of argument against the A-theory. This argument is that there is a certain consequence of any A-theory that is, given other seemingly unobjectionable premises, incompatible with the special theory of relativity (STR). The consequence of particular interest to us is this:

- (1) There is an absolute fact of the matter about which events are simultaneous.

The notion of **really happening** marks, according to A-theorists, an absolute distinction between present events and others. It is obvious that presentists think all events which are really happening are simultaneous, since that view says there is only one moment of time. But non-presentist versions of the A-theory also make use of a single moment such that everything which happens according to it, is really happening (and things which merely were or will happen according to it, are not really happening).² So we may use this notion of really happening to define an absolute notion of simultaneity, specifically:

- (2) p is simultaneous with q (they belong to the same moment of time) iff the way things are is such that: p is really happening and q is really happening.

¹ Zimmerman (2005) contests the claim that the distinction between A- and B-theories lines up with the debate over propositional temporalism.

² Indeed, any consistent A-theory which involves the happening of non-simultaneous events – such as a ‘moving floodlight’ – seems to be forced to adopt a broadly B-theoretic account of property-ascriptions and change for those non-simultaneous happenings (involving covert temporal indices or the like).

Given this definition, and the A-theorists commitment to the absoluteness of ‘really happening’, (1) follows. It is clear that (1) does not follow from the B-theory, because that theory maintains that many non-simultaneous pairs of events exist, and that many non-simultaneous events are jointly really happening, so could never accept definition (2) – even if they were to adopt the ideology of ‘really happening’.

§2. Special Relativity from A to B

The mathematical and physical content of STR goes well beyond what I can present here.³ Thankfully the purported conflict between STR and the A-theory stems from very general features of physical geometry which do not depend on addressing many important matters of detail.

STR is a theory of the geometrical structure of space and time together: Minkowski spacetime. The theory postulates an underlying manifold of spacetime points. The geometrical structure of this manifold can be given by specifying a distance (an **interval**) between any two points, just as we do for ordinary Euclidean spacetime. The details of this distance function are however strikingly different. In Euclidean spacetime, there is just one point that is zero spatiotemporal distance from a given point: itself. But in Minkowski spacetime, there is a non-trivial set of points that have a zero interval from any given point. Moreover, points can even have a negative interval from a given point. We can use the sign of the interval to tell us something about the global structure of spacetime. At any given point p , there will be a collection of points which have zero interval from p – these are **lightlike separated** from p . There will be a collection of points which have positive interval from p , which are **timelike separated** from p . And there will be a collection of points which have a negative interval from p , which are the **spacelike separated** from p . This threefold classification is systematic. The lightlike separated points from p form the surface of (the four-dimensional analogue of) a double cone, called the **lightcone**. The spacelike separated

³ My own presentation is very much influenced by the clear and accessible discussion in Geroch (1978). The chapters by Maudlin and Brown in this volume give more detail as well as some insight into the controversies over the interpretation of STR.

points are those which lie outside the lightcone, and the timelike separated points are those which lie strictly within the lightcone.

The terminology is suggestive. While only the spatiotemporal interval is absolutely given in the underlying geometry, and the interval between two points isn't a spatial or temporal distance, it can nevertheless be decomposed into spatial and temporal components. However, this decomposition is not unique: many different spatial and temporal distance components correspond to the same spatiotemporal interval. We can say this much, however:

1. Whenever the interval between p and q is timelike, the temporal component of every decomposition of that interval is non-zero; though it has no determinate value, it is determinately non-zero.
2. Whenever the interval between p and q is spacelike, the spatial component of every decomposition of that interval is non-zero; though it has no determinate value, it is determinately non-zero.
3. Whenever the interval between p and q is lightlike, the spatial and temporal components of every decomposition of that interval are equal.

Accordingly, the timelike separated points from p are those that can be reached from p by simply waiting for some time to elapse, at least for suitable voyagers. More precisely: any two timelike separated points are such that there possibly exists an object moving in a way not subject to external force (freely falling, or moving **inertially**) whose trajectory passes through both points.

The points lightlike separated from p , falling on the lightcone, are those where the spatial distance matches the temporal distance on every decomposition, so that the interval is 0. Intuitively, points on the lightcone correspond to the trajectory of something moving at some absolute velocity: If we apply the same decomposition process to every point on some lightlike line originating at p , we will get a set of points of uniformly increasing and matched temporal and spatial distance from p . It is a basic truth of STR that it identifies light as the thing which moves with this absolute velocity. The lightcone structure around a point p is by itself sufficient to determine the permissible trajectories for a light ray passing through p .

The possible trajectories for light rays do not depend on the state of motion of their source or any possible observer. This is at variance with our ordinary experience. If we imagine p to be the location of the emission of a physical object, the prior state of motion of the emitter will have a significant effect on the subsequent trajectory of the object. The same is not true of light, which can move only on the paths laid out for it by the underlying light cone geometry.

The physical significance of spacelike separation is dual to that of timelike separated points. These are the points of determinately non-zero spatial separation from one another. Though the spacetime interval doesn't uniquely determine which points are zero temporal distance from one another, there is scope to use the notion of spacelike separation to define regions that intuitively correspond to moments of time:

- (3) A **moment of time** is any region comprising spacetime points T such that
- a. for any $p, q \in T$, p and q are spacelike separated – T is **achronal**; and
 - b. T is maximal: every possible timelike line intersects it once (and only once, given a).
 - c. **Optional:** T is *flat*: there is a timelike line l such that for any $p, q \in T$, p and q lie on a straight line at right angles to ('orthogonal to') l .

This definition – setting aside the optional condition (3c) for now – identifies moments of time with **Cauchy surfaces** (Earman 1995, p 44), and involves only absolutely given geometrical facts. This definition of moments of time is well-behaved, relativistically – indeed, it is well behaved in general relativity as well as STR. So defined, moments of time contain no events that which are determinately separated by a positive temporal interval. Moreover, since each possible observer, whether point sized or larger, intersects any moment of time T just once, and every point on their trajectory not in T determinately occurs at some non-zero temporal distance from the points in T , none of which determinately occur at some non-zero temporal distance from any other point in T . So the moment of time does serve to mark, for every possible object, a division of that object's career into earlier and later; and an achronal region contains no events such that one is strictly already over before the other one occurs. Intuitively, then, these regions behave in many ways like classical moments of time.

The optional condition c requires that a moment of time should be a **flat** Cauchy surface, or a **hyperplane**. (A Cauchy surface is a region such that for any two points within it, there is a decomposition of their interval that makes the temporal separation between them zero. A hyperplane is such that there is a decomposition of the interval d such that for any two points within the region, the temporal separation between them according to d is zero. The difference is in quantifier scope.) If we insist on this flatness condition (Bacon 2016), there is a proof that such regions are uniquely well-behaved as moments of time: *belonging to a hyperplane* is the only non-vacuous equivalence relation definable from the underlying geometry which does not privilege any one point within the moment of time and which is invariant under appropriate symmetry transformations (due to Malament 1977). In general, Cauchy surfaces need not be invariant under such transformations, which is just to say not all of them are flat. Hyperplanes are often called ‘hyperplanes of simultaneity’, because they are associated with Einstein’s operational account of simultaneity (Einstein 1905). This operational definition, like the Malament proof, presupposes that moments of time should be flat. We need not resolve this issue. Below, when I refer to definition (3), the reader with a preference should include or omit the optional condition as they see fit.

Definition (3) is adequate for defining a moment of time in classical spacetime too. But the definition permits moments of time to have features which classical times do not. For example, any moment of time in STR includes some points within it which have positive temporal separation under some decomposition of the interval separating them into spatial and temporal components. But this is not true for every decomposition, so it is false that any moment of time contains points which are determinately at some temporal distance.

More strikingly in STR, unlike classical spacetime, each point p lies within many moments of time. There are many Cauchy surfaces (maximal sets of mutually spacelike separated points) including p . We thus have a tension that arises when identifying the best referent in STR for the classical conception of a moment of time at which p . There are maximal achronal regions containing p , which can be picked out just using the underlying geometry of STR. But there are too many of them, according to the classical conception, which says that each spacetime point occurs in exactly one moment. We may accommodate the classical conception only if we selecting a moment of time for each point, despite there being no geometrical motivation within STR for the selection. Insofar as the A-theory is committed to

the classical conception of moments of time, embodied in (1), this tension is at the heart of the difficulty STR poses for the A-theory.

§3. A Puzzle for STR and the A-theory

Definition (3) of a moment of time uses only mathematical and geometrical notions that are well-defined in STR, since we can define a maximal achronal region in terms just of spacelike separation, timelike lines, and intersection. So, **being a moment of time** is relativistically invariant, as is **belonging to the same moment of time**: if p and q fall within the same maximal achronal region, that is because of the fundamental geometry rather than depending on some specific way of coordinatizing it or representing it. The relation among events of BEING SIMULTANEOUS just is the relation of those events **occurring at or belonging to the same moment of time**. It follows that if two events are simultaneous, that is a fundamental (coordinatization-invariant) geometrical fact in STR.

This may sound surprising to those raised on the idea that simultaneity is relative, that ‘it is of the essence of the theory of special relativity that absolute simultaneity as such does not exist’ (Saunders 2002, p 280). The appearance of conflict is deceptive, but it is instructive to explore it. The standard view about simultaneity that Saunders is invoking is something like this:

- (4) Necessarily, **absolute simultaneity** is:
- a. A **simultaneity** relation, which never holds between events not belonging to the same moment of time, and always holds between events belonging to the same moment of time;
 - b. an **equivalence** relation (reflexive, symmetric, transitive) between points of spacetime; and
 - c. a **unique** and **absolute** relation.

Note that these conditions are jointly satisfiable in classical physics, because the notion *having zero temporal separation* is well-defined and invariant in Galilean spacetime geometry. It can be used to specify moments of time, is an equivalence relation, and is

unique and absolute. This definition of absolute simultaneity is satisfied in classical spacetime.

Recall the A-theoretic account of simultaneity in (2). If the ideology of 'really happening' is acceptable, we can use it to define a simultaneity relation which meets the conditions under (4) for absolute simultaneity. The relation of 'co-happening' is uniquely defined using only absolute notions and it is an equivalence relation. It is by construction a simultaneity relation, since of course the basic premise of the A-theory is that a single moment of time is distinguished in containing all and only the really happening events (or being the moment of time relative to which all and only that which is true *simpliciter* is true). So the most natural A-theoretic conception of simultaneity is a notion of absolute simultaneity.

Saunders' claim that absolute simultaneity does not exist rests on a further principle (2002, p 283):

(5) If it exists, absolute simultaneity is relativistically definable.

Simultaneity is a basic temporal relation. Methodologically, such a relation ought to be identifiable within our best theory of temporal structure. As Hawley puts it, any legitimate simultaneity relation 'would show up in our best scientific theories:... this is just the sort of thing you'd expect science to tell you about' (Hawley 2009, p 511). If (5) is to be respected by the A-theory, we will need to find a relativistically definable relation which is coextensive with A-theoretic simultaneity.

The obvious candidates don't work. We have seen that BELONGING TO THE SAME MOMENT OF TIME is relativistically definable. So it meets condition (5). It is not an absolute simultaneity relation, however, because it is not transitive on our domain of moments of time and so fails to be an equivalence relation. For there being a moment of time to which p and q belong, and there being a moment of time to which q and r belong, do not entail that it is the *same* moment of time being talked about, since q belongs to more than one moment of

time. Indeed, we can readily pick p and r to be timelike separated and yet there be for each of them some moment of time that they share with q .⁴

On the other hand, the relation p AND q BELONG TO T for each specific T is an equivalence relation (which is yet more reason to identify each T with a moment of time, since each moment determines a relation which is formally a simultaneity relation). But of course the many relations p AND q ARE SIMULTANEOUS ACCORDING TO T are explicitly relative to selection of a moment of time, and the selection is not determined by geometry alone (no moment is privileged by the spacetime structure). If we allow them all to be absolute simultaneity relations, we fail to satisfy uniqueness. But there are no grounds internal to spacetime geometry to privilege one of these relations.

In view of the failure of these candidate relativistic definitions of absolute simultaneity, the A-theorist has a few options.

1. **Conciliatory approaches** attempt to alter the definition of a moment of time (3) – which is not, strictly speaking, part of STR but rather a bridge principle connecting STR to ordinary ideology – so as to make BELONGING TO THE SAME MOMENT OF TIME an absolute simultaneity relation.
2. **Antagonistic approaches** say that the failure to identify a relativistically invariant relation co-extensive with the **co-happening** relation is a problem for STR. These approaches further divide over what kind of problem this is.
 - a. **Supplementing** approaches say that STR is not inconsistent with absolute simultaneity, but it – perhaps in common with other physical theories of spacetime – is incomplete with respect to A-theoretic facts.
 - b. **Revisionary** approaches say that STR is inconsistent with absolute simultaneity, so ought to be (and will be, they hope) replaced by some successor theory which does feature a basic absolute simultaneity relation.

⁴ These observations about transitivity are reminiscent of Putnam's (1967) argument, though he considers the 'real for' relation rather than simultaneity, which choice obscures rather more than it illuminates.

I will say no more about revisionary approaches. These approaches agree with the B-theorist that STR and the A-theory are incompatible; they disagree only over whether some successor physical theory will be more hospitable. Proposals about what future physics will hold are speculative, but existing discussions do not uniformly encourage hope for the A-theory (Monton 2006; Wüthrich 2012; Callender 2007; Skow 2015 §9.5).

§4. Conciliatory Approaches

Conciliatory approaches trace the problems for the A-theory to the fact that each point of spacetime is part of many moments of time, according to (3). This is what prevents the relation p AND q BELONG TO THE SAME MOMENT OF TIME from being an equivalence relation. If we can come up with another account of ‘moment of time’ without this problem, perhaps we can reconcile STR and the A-theory. Malament’s result discussed in §2 shows that any rival relativistic definition of MOMENT OF TIME has to give up some plausible features we expect moments of time to have. It is unsurprising that plausible alternative candidates are nevertheless counterintuitive.

One motivation for the A-theory is that the objects of our present experience are apparently more real than objects of merely past or future experience. It is commonsense that my present experiencing falls within a moment of time consisting of just those events that are in some idealised sense perceptible now.

When we gaze into the night sky, I suggest, what we observe is the actual state of the universe, not some causal remnant of its former state. We gaze at the star Sirius and observe its state; not some Sirius-trace which is the antecedent of its actual present state. The latter supposition would suggest that there is some actual contemporaneous state which we cannot know now, but will know later, and I think that special relativity shows us that this is mistaken. (Godfrey-Smith 1979, p 241)

Godfrey-Smith in effect defends this proposal:

- (6) A **moment of time** is any region comprising points lying on the same backwards light cone from some point of spacetime.

In the Malament proof, this definition is excluded by the condition that moments of time should yield a temporal line of symmetry in spacetime.⁵ While this condition is eminently plausible, some suggest that technical considerations favour loosening the requirement that moments of time should be temporally symmetrical. In particular, it has been argued that only definition (6) allows observers moving relative to one another who meet at a point to agree (operationally) on which moments of time that point belongs to (Sarkar and Stachel 1999).

But (6) is a poor definition. If interpreted at face value, each moment belongs to many moments of time, no more permitting an 'absolute' definition of simultaneity than (3). Simultaneity remains non-transitive, since we can pick timelike separated p and r such that p lies on the past lightcone of q , and q lies on the past lightcone of p . And the proposal (which boils down to the proposal that p and q belong to the same moment iff they are lightlike separated) is intrinsically worse than the previous one, since it entails that events which are determinately temporally distant belong to the same moment, and that events which are potentially at zero temporal separation cannot belong to the same moment. According to (6), moments of time are not achronal.

But its defenders will say that using past lightcones to define moments of time, to be used in the standard way to define simultaneity, doesn't capture their intent. Rather, they want to start with a spacetime point presumed to be present, and extend simultaneity ('joint presentness') out from it. Moments of time play no role. On this view, q is **present for** p just in case q belongs to the past lightcone of p . But then if q is present for p , p cannot be present for q , since p will lie on the forward lightcone of q . Whatever else it may be, this is not a simultaneity relation – it is not even symmetric.

These intuitions mustered by supporters of (6) actually emphasise the privileged role of single spacetime points: those at the apex of past light cones, conceived of as the locus of present experiences of events on those lightcones. If we respect those intuitions about present experience, we ought to identify the present moment at p with the set of points (i)

⁵ Each moment of time determines a past and future; if we systematically swap a given past and future, the only region that should remain invariant is the present moment of time.

experiencable at p and (ii) not determinately temporally separate from p . It is trivial that this yields p as the unique point belonging to the same moment as p . That is:

(7) A moment of time is any region consisting of a spacetime point (Sklar 1987, p 302; Savitt 2000 p S567–8).

Simultaneity which makes use of definition (7) meets our conditions (4) and (5) on relativistic simultaneity. But it is also a vacuous relation, ruled out in the Malament proof by the observation that at least two distinct points should belong to any moment of time.

Nevertheless it has its defenders:

in the theory of relativity, the only reasonable notion of “present to a space-time point” is that of the mere identity-relation: present to a given point is that point alone – *literally* “here-now” (Stein 1991, p 159)

Compare: ‘the present instant, properly speaking, does not extend beyond the here’ (Robb 1921, p 13).

It is strikingly counterintuitive to say that all that is really happening at any moment is a single point-sized event. Definition (7) has been said to be ‘obviously untenable’ (Saunders 2002, p 286), and in conflict with the ‘the common sense picture that motivates the A-theory [that] the present is spatially extended and so public and shareable’ (Gilmore, Costa, and Calosi 2016, p 109).

But perhaps more troubling for the A-theory is how to account for change in what is really happening over time. There is one moment of time (point-region of spacetime) which corresponds to how reality *is*. Part of how reality *is* consists of how it currently was and currently will be. The only viable semantics, given (7), for past tense ‘was’ is this: ‘it was the case that ϕ ’ is true iff there is a moment of time q in or on the past lightcone of the present moment at which ϕ .⁶ Suppose ϕ is true only at some moment spacelike separated from the present moment. This is true: ‘it will be that it was that ϕ ’. But it is not true that ϕ ; nor was it true that ϕ ; nor will it be true that ϕ . This conflicts with platitudes about time, such as that if something hasn’t yet been, but it will have been, then it will come to be (Bacon

⁶ Any rival semantics for *was* which classified some spacelike separated points as past could be used to extend the present from a single point to an extended region of mutually spacelike separated points, and would end up closer to definition (3).

2016). Some dismiss such platitudes – ‘so what?’, says Skow (2015, p 166). But violate too many platitudes, and the ‘moments of time’ we end up with aren’t worth the name.

§5. Supplementing Responses

The upshot of the previous section was that no rival account of moments of time was both viable and more accommodating to the A-theory than definition (3). Supplementing responses to the problem of absolute simultaneity adopt that definition, but appeal to some additional facts – not grounded in the geometry of STR – to pick out that moment of time such that the events occurring at it are just those that are **really happening**. These views thus deny assumption (5), and argue that STR lacks the resources to capture the A-theoretic facts about absolute simultaneity. It is in this sense that Saunders and many others hold the A-theory to be ‘inconsistent’ with STR: that A-theory ideology in (2) requires a notion of simultaneity that rejects the adequacy of STR as encapsulated by (5).

A model of STR yields a tenseless mosaic or manifold of all that ever happens and the spatiotemporal relations between these happenings. What it is for a model to be true is for the overall structure of spacetime and its occupants to correspond to the model. Facts represented in this manifold collectively form a supervenience basis for modelling the paths and changes in material things, predictions of relativistic measurements, and the trajectories of light signals. But contrary to Hawley’s remark quoted in §3, it would be quite inappropriate for temporary facts – such as those about what is really happening now – to appear in this representation of what is permanently true. Nor do ‘dynamic’ facts about the coming into being over time of the tenseless manifold appear in the manifold.⁷ But that doesn’t mean that those temporary facts are not facts – only that it is not part of the remit or ambition of STR to represent them.

The most common kind of supplementing response is to simply add the A-theoretic ideology to STR:

There is a region of the manifold in which events are really happening, it includes [my present location] and many other points, and it does not

⁷ Like an ordinary mosaic, the finished image doesn’t betray the order of its construction.

coincide with any region that is geometrically distinguished, according to SR. (Zimmerman 2011, §3)

Models of this theory involve at least a STR manifold together with a specification of the moment of time N which is the uniquely accurate moment.⁸ The purest version of such theories takes the A-theoretic ideology to be in perfectly good standing in its own right, and uses (2) to pick out the privileged moment, regardless of whether the privileged moment has any further special physical features or special material contents. Such a theory adopts existing explanations in STR wholesale, but adds new explanatory capacities, since now the whole panoply of tensed facts can be given grounds in this additional A-theoretic structure.⁹

Such supplementing views admit a body of facts which STR was already sufficient to explain, including all the physical facts about material objects, their nature and behaviour at every point, and the causal relations between regions of spacetime. Such facts remain constant and explained in the same way regardless of which moment is privileged. This gives rise to two related objections:

- An epistemic objection: the physics of measurement devices, including our own sensory apparatus, supervenes just on the manifold and its contents. So the A-theoretic structure would be undetectable (Savitt 2000, p S570): concerning the model which happens to privilege the actual present, 'it is impossible to know that it, rather than some alternative ..., is the true one' (Skow 2015, p 157). Indeed, if there is a privileged present, no one could know that there is, since pure STR models without a privileged present are explanatorily adequate to physical experience.
- A theory which posits a privileged moment in addition to pure spacetime geometry is 'guilty of a commitment to surplus geometrical structure ...which is standardly taken to be a theoretical vice' (Gilmore, Costa, and Calosi 2016, p 109). The sole reason to postulate A-theoretic structure is to accommodate tensed facts – no

⁸ Depending on details of how the tense operators are to be handled, we may also need to be inegalitarian about which moments of time wholly to the past (future) of N are involved in grounding truths about what was (will be). Zimmerman, for example, argues for a privileged foliation as well as a privileged moment.

⁹ Some argue that such additional structure can be motivated by consideration of physics going beyond STR: Dolby and Gull 2001 (but see Eagle 2005); Forrest 2008. We here stray into the territory of revisionary theories, however.

physical grounds motivate this addition, and it is methodologically vicious because ‘scientific methodology is always against superfluous pomp’ (Callender 2007, p 67).¹⁰

Against the methodological objection one might reply: we accept plenty of ordinary objects that are not explicitly mentioned in the physics – there is structure at the level of dogs and people and material artefacts that genuinely exists even though it is not unambiguously identifiable with the structure of (collections of) point particles (Zimmerman 2008, p 219). A commitment to rocks and clouds over and above pluralities of rock- and cloud-parts is anodyne, but nevertheless seems to fall foul of this supposed methodological principle.

However, we have lots of evidence for the existence of rocks and clouds. If the methodological principle is weakened to say that it is theoretically vicious to accept surplus structure without evidence, few will question it. The problem for the supplementing response is that the epistemic objection does seem to undermine our evidence for tensed facts. If our experience supervenes on the physical, and that experience is thus insensitive to whether STR or some supplemented model of STR is accurate – an insensitivity which both A-theorists and B-theorists agree exists – we might wonder: how can that experience be evidence for the additional A-theoretic structure? This is not simply an objection that the experience would be the same regardless of whether STR is supplemented or not (Price 1996, pp 14–5). The objection is that the **explanation** of the experience is the same, so that the postulated privileged moment is explanatorily idle with respect to precisely the experiential phenomenology that is supposed to motivate the postulation. As Savitt puts it, ‘If the present [moment] is indeed so elusive, I find it difficult to imagine what aid or comfort it could be to a metaphysician’ (Savitt 2000, p S570).

Of course, the present isn’t *entirely* elusive. If my present experience is of p , then I know that the present moment is an achronal region including p . Our knowledge of the privileged moment will not extend further than this however; our experience is casually connected only with things that were (within the past lightcone of p) and every moment of time which

¹⁰ Sometimes this methodological objection is raised as the principle that the basic truths – including those about absolute simultaneity – ought to be invariant under spacetime symmetries (Skow 2015, p 148; Earman 1989, pp 45–7). This boils down to a bare insistence that only conciliatory A-theories can be right, so is dialectically inappropriate.

might be the privileged one agrees that those things were. And, of course, if the only point invoked in the account of my current experience is the point event of that experience p , then it must be noted that even the B-theory gives that point some special significance for my current thought and talk, albeit significance of a merely indexical sort.

The bolder response for the A-theorist is to reject the idea that the explanation of my present experience is a physical one. This would be to bolster the A-theory by appeal to a more thoroughgoing incompleteness of physics with respect to phenomenal experience. If STR is supplemented only with a privileged moment, the role of that additional structure is purely epiphenomal with respect to explanations of experience. If we don't like that, we can discard the excess structure, and with it the A-theory – or we can reject the adequacy of physical explanations of tensed experience in favour of a robustly non-physicalist A-theory on which the conscious experience as of a privileged present moment is both veridical and has no complete physical explanation. This may be a consistent proposal, but it certainly has the misfortune of yoking the A-theory to a speculative philosophy of mind whose substantive content appears to go well beyond the relatively banal grounds offered in favour of the A-theory in §1.

These orthodox supplementing A-theories are consistent with STR and the A-theory. If our prior confidence favours the A-theory, the availability of such packages may be enough to allow us to continue to maintain that belief in light of scientific evidence. Perhaps the tenability of the A-theory given STR is enough for some A-theorists (Zimmerman 2011). But nothing in these packages looks like a positive reason to come to accept the A-theory, since the substantive explanatory work done by the supplemented theories is parasitic on that explanations provided by unsupplemented STR.

I wish to briefly mention an unorthodox supplementing theory (Bacon 2016), on which A-theoretic moments of time are not to be identified with regions of spacetime at all, but are instead ways of mapping families of temporary properties to hyperplanes at which permanent correlates of those properties may be instantiated. These mappings are obviously not part of the manifold, and so this is a supplementing theory. The details are unfortunately too complicated to discuss here. The theory is arguably egalitarian about hyperplanes, since a time associates every hyperplane h with some tensed properties

sufficient to correctly describe the entire manifold as if from the perspective of h . How then can we say that some events in the manifold are really happening while others are not? Bacon says: at each time, each hyperplane h is such that the events on it have a temporary property RH_h , but each timelike line is associated with a context that picks out one such property as the referent, in that context, of 'really happening'. Given my present context, just one hyperplane is really happening given the present time; but for every other hyperplane, there is a context (some of which are monstrous) where 'really happening' picks out the property had just by events at that hyperplane. Whether this contextualist version of the A-theory provides enough metaphysical 'oomph' to satisfy A-theoretic intuitions is debateable, but it does indicate the contortions that A-theories which try to respect egalitarianism about moments of time are forced into.

§6. Whither the A-theory?

There is no knock down argument from STR against the A-theory, though we ought to lower our posterior confidence in that theory in light of relativistic physics. The A-theoretic picture of a wave of simultaneous happenings that sweeps through time, grounding tense in the four dimensional manifold, is not straightforwardly compatible with STR, a tension dramatized by attempts to locate or impose a relation of absolute simultaneity on Minkowski spacetime. But A-theories more or less deserving of the name can be defended by weakening our aspirations for how absolute simultaneity is to be found in STR, by rejecting (5).

Over time, however – and especially given semantic and metaphysical difficulties for the A-theory and related doctrines such as propositional temporalism – it appears that attempts to marry the A-theory with STR are more trouble than they are worth. If our most widely adopted theories of truth conditions involve truth relative to worlds but not times, and more of us have prior confidence in 'block universe' interpretations of the physics, there is decreasing pressure to find any fundamental theoretical role for moments of time – let alone some special metaphysical significance for a specific moment of time. These trends in philosophical views are no doubt accelerated by the widespread consideration of STR, and the clear difficulties in locating moments of time that behave as we wish in that theory. But

‘one can only extract so much metaphysics from a physical theory as one puts in’ (Sklar 1987, p 291). We can put enough A-theoretic metaphysics into the pure theory of spacetime geometry to get out a consistent theory. But we don’t need inconsistency to appear in order to realise we might be better off overall with the B-theory.¹¹

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¹¹ Turner 2020, published as this chapter was going to press, makes some related arguments.

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