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Presentism and Relativity*

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Abstract

In this critical notice we argue against William Craig's recent attempt to reconcile presentism (roughly, the view that only the present is real) with relativity theory. Craig's defense of his position boils down to endorsing a "neo-Lorentzian interpretation" of special relativity. We contend that his reconstruction of Lorentz's theory and its historical development is fatally flawed and that his arguments for reviving this theory fail on many counts.

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*A critical notice on Craig 2000a, 2000b, and 2001a.

1 Rival Theories of Time

According to the tensed theory of time, reality is characterized by objective tense determinations of *being past*, *present*, and *future*. On the rival tenseless theory, no such determinations are objective. Rather they are features of a particular perspective on reality, a reality which is not itself tensed. No events or moments of time are by themselves past, present, or future. They only become so when viewed from a given vantage point in time, *t**. They can then be described as being past, present, or future, but what make such descriptions true are the tenseless facts that the events in question occur, respectively, *earlier than*, *simultaneous with*, or *later than t**. There is nothing special about *t**. Any other moment can serve as a focal point of a perspective on other times, because all moments of time and their contents are on the same ontological footing. They tenselessly exist at their respective dates, much like different places and their occupants exist at their respective spatial locations.

The issue between the two rival views—alternatively (but not always correctly, but we gloss over that) labeled the 'A- and B-theories' (following McTaggart), 'dynamic' versus 'static time', 'presentism' versus 'eternalism', 'real time' versus 'spacelike time'—remains central in the flourishing philosophy of time industry. William Lane Craig's monumental tetralogy (Craig 2000ab, 2001ab) is both a state-of-the-art survey of the entire field and an uncompromising defense of (a version of) the tensed theory. The scope of Craig's study, summarizing (but also going beyond) what he and others have done in the field in the past twenty years or so, is overwhelming and the amount of detail staggering. We venture to say that no single important argument for or against any of the two rival views of time is left unaddressed by Craig and challenge the reader to find such an argument. (But see below for his less fulfilling discussion of the related issue of persistence). He traces the evolution of the B-theory from the old "translation thesis" to the new "truth-conditions" claim, making the motivations and pressures involved in the transition highly perspicuous. He examines in detail the experience of time and devotes a good fifty pages to McTaggart's paradox. He literally takes the issues of temporal passage and becoming apart. In particular, Craig presents, in the second volume, a series of arguments against the mind-dependence interpretation of becoming and the "spatializing" of time. In that volume he also explores the connections between the nature of time and the ontology of persistence. Last but not least, he attempts to undermine the B-theorist's reliance on relativity theory by undertaking a comprehensive philosophical study of this theory. We are sure many readers will find most of Craig's central claims controversial and some of his tactics (e.g., ample use of theological considerations in philosophical argumentation) questionable. But he succeeds, we think, in challenging his opponents. In any event, we feel challenged and are aware of other critical responses, some in print, some still brewing in the works, to various strands in Craig's extended defense of the tensed theory and his assault on its tenseless rival. Needless to say, it is not possible to do Craig's work full justice here. To make the subsequent discussion focused, we have chosen to concentrate on what seems to us most provocative and most misguided: Craig's attempt to reconcile the presentist version of the tensed theory with relativity. To warm up, however, let us first make a comment or two on a different (but remotely connected) issue of the relationship between the nature of time and the ontology of persistence.

2 Time and Persistence

Recent work on persistence through time has produced a more fine-grained inventory of views than we had a few years ago. Although there are still two major rival accounts on the market, three-dimensionalism (3D, endurantism) and four-dimensionalism (4D, perdurantism), distinct varieties of each view have now been identified. Thus philosophers who think that ordinary material objects endure—that they are wholly present at all times at which they exist—now explicitly include those who prefer to run this position together with a certain theory of time, namely *presentism*,[1] and those who deny this link between the theory of persistence and the philosophy of time.[2] Similarly, four-dimensionalists who think objects perdure—persist by having different temporal parts at different times—comprise those who think that this position presupposes the B-theoretic ontology,[3] as well as those who argue against this connection.[4] Endurantism and presentism are undoubtedly natural partners—just as perdurantism and eternalism are. The interesting question, however, is whether members of these pairs *entail* each other. Craig sides with those who think they do (2000b, Ch. 9). In particular, he argues (ibid., pp. 184–191) that the combination (defended, among others, by Mellor, van Inwagen, Rea, Lowe, Johnston, and Haslanger) of endurantism with the B-theory of time is implausible. In our view, his argument is inconclusive.

The question eventually boils down to the famous problem of temporary intrinsics. The endurantist who is also a B-theorist has to explain how numerically the same three-dimensonal object can have incompatible intrinsic properties *F* and *not-F* at different moments of time t_1 and t_2, at which it is wholly present. Arguably, the best solution on behalf of such a theorist is *adverbialism*: object *O* has property *F* in a *certain way* characterized by the temporal modifier t_1, and it has *not-F* in a *different way* characterized by t_2. Craig complains (2000b, pp. 186ff) that this inappropriately privileges the temporally qualified having of intrinsic properties over having

[1] See, e.g., Merricks (1994, 1995), Hinchliff (1996), Zimmerman (1998).

[2] See Mellor (1981), Johnston (1987), Haslanger (1989), van Inwagen (1990), Lowe (1987), Rea (1998).

[3] Most four-dimensionalists are B-theorists. Merricks (1995), who is a three-dimensionalist, and Carter and Hestevold (1994), who maintain a neutral position, have nonetheless argued for the link between perdurantism and the tenseless theory of time.

[4] Brogaard (2000) defends presentist four-dimensionalism. Although not presentist four-dimensionalists themselves, Lombard (1999) and Sider (2001, §3.4) have argued that this combination is consistent.

them *simpliciter*.[5] But why is it inappropriate? As noted by Rea (1998, p. 245), "it does not seem to follow from the fact that 'being F' is an ingredient of 'being *t*ly F' that it is possible for something simply to be F." The adverbial nature of property instantiation appears to be a common phenomenon. Using Rea's example, the fact that *running* φ*ly* (e.g., slowly or quickly) can be analyzed in terms of *running simpliciter* does not entail that it is possible for something to run *simpliciter* (i.e., without at the same time running slowly or quickly or otherwise). Craig is aware of this and responds as follows: "The issue is not one of ontology, but semantics. The question is what notion is semantically primitive. *Running* φ*ly* … is not semantically primitive because it can be analyzed in terms of the more primitive notion *running*. But on adverbialism there is no such notion as having a property *simpliciter*. The apparently complex notion of having a property *t*ly must be taken as semantically primitive, which to all appearances it is not" (2000b, p. 191n37). But should a correct semantics be a matter of "appearances"? This is hardly a reasonable requirement (recall the semantical quandaries of descriptions and propositional attitudes). Craig's critique thus begs the question. Starting with the basic expression 'O is$_t$ φ', where 't' modifies the copula, we can then analyze 'O is φ' along the lines of '$\exists t$ (O is$_t$ φ)', just as we can analyze *running* in terms of *running somehow* (e.g., slowly or quickly).

Craig's (unavailing, in our opinion) attack on adverbialism is part of his chapter-long attempt to favor the presentist endurantism solution to the problem of temporary intrinsics over all other candidates. Unfortunately, his discussion does not take into account important recent developments in the 3D/4D debate. In particular, it overlooks a distinction that has emerged within the perdurantism camp, one between the *worm* theory and the *stage* theory. The worm theory features an ontology of 4D wholes (spatio-temporal "worms") occupying determinate

[5] He is not alone in this complaint. Cf. Merricks 1994.

regions of spacetime. Such entities have parts, or stages, each of them confined to a particular time (an instant or interval). The stage theorist, on the other hand, maintains, not that perduring objects have stages, but that the fundamental entities of the perdurantist ontology *are* stages.[6] The stage theory claims a number of advantages over both endurantism and the worm view. Thus its advocates have argued that the theory offers the best unified solution to the paradoxes of material constitution and coincident entities and to the problem of vagueness.[7] In addition, the stage theory meets the desideratum (if it is a reasonable one to have) of making objects of ordinary discourse (i.e., stages) have their temporary intrinsics *simpliciter* (in this connection, see, especially, Sider 2001, §§4.6, 5.8). While the stage theory may or may not be correct,[8] it is certainly a major player in the 3D/4D debate and thus is not to be ignored.

Going back to the alleged commitment of the endurantist to presentism, and hence of the B-theorist to perdurantism, we believe Craig's analysis so far does not warrant his rather categorical statements to this effect scattered throughout his work.[9] Not being endurantists ourselves, we think Craig's failure to substantiate such claims is good news for endurantism, as it gives its advocates more room to maneuver. Indeed, some endurantists are reluctant to accept the tensed view of time, citing, as an important reason, its incompatibility with relativity theory.[10] Breaking the link between endurantism and presentism (or, rather, failure to establish it in the

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[6] The stage theory has recently been elaborated and defended by Sider (2001) and Hawley (forthcoming). References to earlier works can be found therein. The paradigm worm theorist is probably Heller (1990).

[7] Craig's discussion barely touches on the first and practically ignores the second. Since both are now big metaphysical industries, this makes Craig's arguments in the chapter on persistence and his final verdict far from being up-to-date in yet another respect. In fact, his overlooking the stage theory makes most of his objections to perdurantism in 2000b, Ch. 9 ineffective.

[8] One of us has recently expressed doubts whether the stage theory can be given an acceptable relativistic formulation. For arguments, see Balashov 2002.

[9] "Spacetime realism [i.e., the view that all events populating the 4D spacetime manifold tenselessly exist on the same ontological footing] raises a host of problems due to its *entailment* of the doctrine of perdurance …" (2000b, pp. 124–5, our emphasis; cf. 2001a, p. 192); "If one is a spacetime realist, then, barring conventionalism, things must have spatio-temporal parts" (ibid., p. 202n68); "A consistent spacetime realist will … view objects as spatio-temporal entities which perdure" (2001a, p. 94n54).

[10] See, e.g., Johnston 1987, pp. 114–115; Rea 1998, p. 238.

first place) makes it prima facie possible to accommodate endurantism within the framework of relativity (see, in this connection, Sider 2001, §4.4). We believe it does not, in the end, work out, but one has to produce independent arguments to this effect (see, in this connection, Balashov 1999, 2000a, 2000b)—independent, that is, of what appears to be a straightforward refutation of presentism by contemporary spacetime theories.

Craig, however, sets out to turn the tables rather dramatically on that score, by arguing that, in the conflict between presentism and Special Relativity, it is the latter—or, more precisely, what Craig takes to be a particular interpretation thereof—that has to give. In fact, his arguments for this bald thesis constitute the essence of the entire third volume (Craig 2001a) and a half of the second (Craig 2000b).[11] Craig's strategy there merits careful examination.

3 Relativity and the Present

Presentism is, roughly, the view that only the present exists. The advocate of this doctrine is therefore committed to there being a fact to the matter of what events on Pluto are present (hence real) when John snaps his fingers here on Earth. Special Relativity (SR) denies that there are any such facts. Craig contends that facts about absolute simultaneity and the absolute present have a place in SR after all, provided this theory is given a suitable, "neo-Lorentzian" re-interpretation, and argues that this re-interpretation is physically acceptable, as well as metaphysically preferable to the standard formulation. Unlike some other A-theorists who tend to ignore, evade, or table the relativistic objection, Craig confronts it head-on. We believe his arguments all fail, but it is not entirely trivial to see why they fail.

[11] The reader should be warned that there is considerable overlap between Craig 2000b and 2001a. In fact, the entire material on relativity contained in Craig 2000b, pp. 11–126, is reproduced verbatim in Craig 2001a. Hence the reader specifically interested in relativity can safely confine her/himself to Craig 2001a.

Craig's volume-long defense of the neo-Lorentzian interpretation touches on many issues ranging from history of relativity to scientific methodology to the foundations of spacetime theories. Responding in detail to what Craig has to say on all of these topics would probably require another volume of comparable length. We want to focus on what we think is the central issue. Because of his metaphysical and theological predilections, Craig wants to resurrect the notion of a preferred frame of reference in physics. We want to show—no more and no less—how forcefully the *physical* evidence militates *against* such a return to the days before Einstein. We claim (see sec. 11 below) that the argument from physics against Craig's metaphysically motivated proposal is on a par with the argument against proposals to return to the days before Darwin in biology or the days before Copernicus in astronomy.

We want to preface our discussion with a cautionary note on the genre of Craig 2001a. This volume should be looked upon not so much as a "philosophically-informed introduction to relativity theory" (p. ix; unless otherwise indicated, page references below are to Craig 2001a) but as an exposition of a highly controversial view of this theory by a philosopher who has an active agenda (and much at stake). For this reason, we would not recommend it to a philosophically-minded beginner wanting to *learn* SR. Such a reader is much better off reading, for instance, Geroch 1978 or Sartori 1996.[12]

4 Special Relativity: One Theory, Three Interpretations

Craig distinguishes three interpretations of SR: (1) the "Relativity Interpretation," which is essentially the form in which Einstein (1905) originally presented his theory; (2) the "Space-Time Interpretation," which is essentially the geometrical interpretation that Minkowski (1909)

[12] We should warn the reader, however, that Sartori (1996, pp. 123–128) fails to do justice to Lorentz's theory (see Janssen 2002 for a concise characterization of Lorentz's theory and its development).

gave to Einstein's new kinematics; (3) the "Neo-Lorentzian Interpretation," which is a modernized version of (the relevant parts) of the classical theory of Lorentz (1915) in its final form. We can take the theory itself to be the requirement that all physical laws—or at least all laws effectively governing observable phenomena—be Lorentz invariant. A historian of relativity will have to be more careful, but for our philosophical purposes, as well as for all practical purposes of modern physics, this characterization is perfectly adequate. We also have no trouble with Craig's taxonomy of the theory's interpretations, even though many physicists and philosophers would exclude the neo-Lorentzian interpretation since it runs counter to the spirit if not the letter of SR by retaining a preferred frame of reference and absolute simultaneity. For us, it is Craig's analysis of these three interpretations and the relation among them, that is problematic.

5 Theories of Principle and Constructive Theories

What Einstein presented in his 1905 paper is basically—the reason for the qualification will become clear below—what he would later call a "theory of principle" as opposed to a "constructive theory" (Einstein 1919). Einstein used the examples of thermodynamics and statistical mechanics to illustrate this distinction. Here is our understanding of the distinction. In a theory of principle, one starts from some general well-confirmed empirical regularities that are raised to the status of postulates (e.g., the impossibility of perpetual motion of the first and the second kind, which became the first and second laws of thermodynamics). With such a theory one explains the phenomena by showing that they necessarily occur in a world in accordance with the postulates. Whereas theories of principle are about the *phenomena*, constructive theories aim to get at the underlying *reality*. In a constructive theory one proposes a (set of) model(s) for some part of physical reality (e.g., the kinetic theory modeling a gas as a swarm of tiny billiard balls bouncing around in a box). One explains the phenomena by showing that the theory provides a model that gives an empirically adequate description of the salient features of reality.

Consider the phenomenon of length contraction. Understood purely as a theory of principle, SR explains this phenomenon if it can be shown that the phenomenon necessarily occurs in any world that is in accordance with the relativity postulate and the light postulate. By its very nature such a theory-of-principle explanation will have nothing to say about the reality behind the phenomenon. A constructive version of the theory, by contrast, explains length contraction if the theory provides an empirically adequate model of the relevant features of a world in accordance with the two postulates. Such constructive-theory explanations do tell us how to conceive of the reality behind the phenomenon.

Both the space-time interpretation and the neo-Lorentzian interpretation provide constructive-theory explanations. In the space-time interpretation, the model is Minkowski space-time and length contraction is explained by showing that two observers who are in relative motion to one another and therefore use different sets of space-time axes disagree about which cross-sections of the "world-tube" of a physical system give the length of the system. In the neo-Lorentzian interpretation, length contraction is explained as a combination of dynamical effects and artifacts of measurement. We shall examine this explanation in more detail below.

As long as we view SR *strictly* as a theory of principle in the sense in which it was defined above, there are no grounds for preferring one constructive-theory explanation over another. Einstein's theory, however, was *not* purely a theory of principle. In the "Kinematical Part" of the 1905 paper, Einstein made it clear that he saw the effects derived from the postulates as manifestations of a new kinematics. So despite Einstein's initial misgivings about Minkowski's ideas and their mathematical expression, the space-time explanation of phenomena such as length contraction is completely in the spirit of Einstein's theory, whereas the neo-Lorentzian explanation is not. One of us has argued (Janssen 1995, sec. 4.3.1; 2002) that Lorentz himself was able to reconcile his own theory with SR by looking upon the latter strictly as a theory of principle.

6 The Relativity Interpretation: Explanatorily Deficient?

In this section and the next, we respond to Craig's objections to the relativity interpretation. Craig writes: "the relativity interpretation of SR with its pluralistic ontology and contracted and retarded three-dimensional continuants, is fantastic and explanatorily impoverished" (p. 102). We shall deal with the "fragmented-ontology" objection and the "explanatory-deficiency" objection in turn.

The explanatory-deficiency charge has two counts. (*i*) SR in its 1905 form fails to provide a theory-of-principle explanation of phenomena such as length contraction. (*ii*) Theory-of-principle explanations in general are deficient. We begin with (*ii*). First, we note that theory-of-principle explanations appear to fit the once-standard covering law model of explanation much better than constructive-theory explanations. That, however, might just be another nail in the coffin of the covering law model. More importantly, we want to emphasize that (*ii*) also applies to thermodynamics. That in and of itself, we submit, places the relativity interpretation in very good company.

Having said this, we must grant Craig that Einstein himself appears to have thought that theories of principle are inferior to constructive theories. If this is so, one may ask why he settled for a theory of principle in 1905. The answer can be found in an oft-quoted passage from Einstein's autobiographical notes: “By and by I despaired of the possibility of discovering the true laws by means of constructive efforts based on known facts. The longer and more despairingly I tried, the more I came to the conviction that only the discovery of a universal formal principle could lead us to assured results. The example I saw before me was thermodynamics” (Einstein 1949, p. 53). Einstein settled for a theory of principle because he was confident that the two postulates on which he built his theory would survive the quantum revolution he saw coming.

This brings us to another remark by Craig: “As a theory of principle rather than a constructive theory, Einstein’s SR is based on postulates which are characterized by their very non-empirical character” (p. 181). In fact, like the first and second laws of thermodynamics, Einstein’s two postulates rest on a wealth of empirical evidence. The relativity postulate was supported by nearly a century’s worth of failed attempts to detect the earth’s motion with respect to the ether (see, e.g., Janssen and Stachel, forthcoming). Einstein did not cite any empirical support for the light postulate in the 1905 paper. This reticence has led many later commentators (though not Craig) to misread the light postulate as a sweeping generalization of the negative result of Michelson and Morley. As was first explained in Einstein 1911 (p. 6) and as was emphasized in many of his subsequent expositions of SR, however, Einstein saw the light postulate as the secure core of classical electrodynamics. So, indirectly, the light postulate is supported by all the evidence amassed during the 19th century in favor of that powerful theory.

We now turn to count (*i*) of Craig’s explanatory-deficiency charge, which seems to be the upshot of Craig’s discussion (pp. 27–42) of the alleged conventionality of simultaneity in SR. Neither length contraction nor the Lorentz transformation equations for the space and time coordinates can be derived solely from the postulates. One also needs the appropriate assumptions about the homogeneity and isotropy of space and time (explicitly identified in the 1905 paper and routinely granted) and the Einstein-Poincaré convention for synchronizing distant clocks. Consider two clocks *A* and *B* at some distance from one another at rest in some frame *S*. When *A* reads t_1, a light signal is sent to *B*. The signal arrives at *B* when *B* reads t_2, and is reflected back to *A* where it arrives when *A* reads t_3. *A* and *B* are said to be properly synchronized in *S* if and only if $t_2 = t_1 + \frac{1}{2}(t_3 - t_1)$.

First of all, we want to emphasize that the use of light signals is by no means essential to define simultaneity in any one frame. They could be replaced by bullets fired from *A* to *B* and from *B* to *A* by identical guns at *A* and *B*. We cannot use bullets, however, to establish the *relativity* of simultaneity *until* we have established how their velocities transform in a world in accordance with the postulates. Light is the only signal for which the postulates tell us how its velocity transforms. So we introduce the concept of simultaneity in terms of the light-signaling method, use the result—along with two further consequences of the postulates, length contraction and time dilation—to establish the transformation rule for arbitrary velocities in a relativistic world, and then verify that it makes no difference whether we use light signals or bullets moving with subluminal or even superluminal velocities to synchronize clocks.[13]

What is at issue in the debate over the conventionality of simultaneity is whether the definition of simultaneity involving the Einstein-Poincaré light-signaling method is not just based on an arbitrary choice of $0 < \varepsilon < 1$ in the expression $t_2 = t_1 + \varepsilon(t_3 - t_1)$. As Craig reports, Malament (1977) showed (or claimed to have shown[14]) that the standard definition, based on $\varepsilon = \frac{1}{2}$, is the only (nontrivial) simultaneity (equivalence) relation that can be defined completely in terms of

[13] This argument is due to Jon Dorling, formerly at the University of Amsterdam, and was imparted to one of us (MJ) as a student. Several of the arguments presented here are based on Dorling's insightful observations.

[14] Sarkar and Stachel (1999) claim to have found a loophole in Malament's proof. For a response and a new challenge to Malament's result, see Rynasiewicz 2000 and 2001, respectively.

the causal structure of Minkowski space-time and an observer's world line. Craig grants that, *given* Minkowski space-time, the standard definition is unique, but, he writes, "to justify the definition … by appealing to the metric of relativistic space-time would plainly be question-begging" (p. 35, see also p. 42).

The problem is much more benign than Craig makes it sound. First, Craig's objection loses much of its force when we recognize the space-time interpretation as a constructive theory *complementing* the theory-of-principle-type relativity interpretation rather than as one of its rivals. We could then simply concede that a rigorous argument proving the uniqueness of the standard definition of simultaneity had to wait for the development of the space-time interpretation. Or we could try to rewrite Malament's argument for the uniqueness of the standard definition of simultaneity in terms of the relativity interpretation. We do not even have to concede or do that much. We can justify the standard definition without appealing to Minkowski space-time. Making the appropriate assumptions about homogeneity and isotropy, we demand that ε be chosen in such a way that the velocity of light moving from *A* to *B* comes out to be equal to the velocity of light moving from *B* to *A*.[15] The standard objection to this line of reasoning is that the one-way velocity of light can not be defined in the absence of a definition of simultaneity. But for the purpose of defining simultaneity, a necessary condition for any acceptable definition of velocity suffices. Making the assumptions of homogeneity and isotropy, in turn, suffices to justify that condition:[16] equal distances traveled at the same velocity should take equal times.

[15] To our knowledge, none of the proponents of the conventionality thesis has ever shown that alternative values for ε lead to velocity transformation equations such that the results of synchronization with bullets give the same results as synchronization with light. This would seem to be another condition that should be imposed on the choice of ε, a condition for which once again we only have to invoke isotropy, not the specific structure of Minkowski space-time.

[16] This argument will carry little weight with the conventionalist who will presumably respond that the assumptions of isotropy and homogeneity are themselves conventional, but for our purposes that does not matter.

In short, Craig's explanatory-deficiency objection fails on both counts. The explanations given by the relativity interpretation are (*a*) as good as the theory-of-principle explanations of thermodynamics and (*b*) independent of the space-time interpretation (not that (*b*) matters much from our point of view).

7 The Relativity Interpretation: Ontologically Fragmented?

It is part of the nature of theories of principle that they avoid ontological commitments as much as possible. Craig nonetheless claims that the relativity interpretation is committed to an ontology of ordinary three-dimensional objects with definite length, width, and height. Since these properties are frame-dependent, Craig claims that the relativity interpretation leads to what he calls the "fragmentation of reality" (p. 104). These charges are unfounded. Borrowing a phrase from Norton (1999), Einstein follows a "subtractive" strategy in his 1905 paper. He certainly discusses ordinary three-dimensional objects, but the point of that discussion is to show that many properties such objects have intrinsically in the classical world (such as their length) become frame-dependent in a world in accordance with the postulates of relativity theory. Rather than endorsing an ontology of three-dimensional objects, Einstein actually strips such objects of many of their classical properties. A clear example of Einstein's strategy is his treatment of electromagnetic fields. Craig's fragmented-ontology charge would have Einstein commit to the existence of two separate fields, electric and magnetic, ontologically different in different frames. In fact, what Einstein is arguing is that there are no separate electric and magnetic fields, but only a new entity, the electromagnetic field, which splits into an electric and a magnetic field in a frame-dependent manner.

Einstein's usage of a "subtractive" strategy shows how close the relativity interpretation is to *Minkowski's version of* the space-time interpretation. In modern texts (e.g., Earman 1989), space-time theories are formulated following what Norton (1999) calls the "additive" strategy. In this approach, which goes back to Riemann, one starts with a bare manifold and then adds geometrical structure, for example, a metric or an affine connection. Minkowski, by contrast, worked in the tradition of the Erlangen Program of Felix Klein (1921, pp. 411 ff.). In this approach geometries are characterized in terms of invariants of transformation groups associated with them. Reality is denied to all elements not invariant under the relevant group of transformations. In the case of SR, this group is the Lorentz group. So, Minkowski, like Einstein, followed a "subtractive" strategy. Minkowski (1909, p. 83) even suggested to change the name 'relativity postulate' to 'postulate of the absolute [four-dimensional] world' to put more emphasis on the new relativistic ontology instead of on the discarded—relative or frame-dependent—elements of the old ontology. Felix Klein (1910, p. 539) likewise suggested that the relativity theory might as well be called the 'invariance theory' (of the Lorentz group). Einstein agreed (see Holton and Elkana 1997, p. xv) but neither suggestion caught on.

8 The Space-Time Interpretation: Does God Need a Preferred Frame of Reference?

We only have a few points to add to what has already been said about the space-time interpretation. Craig (pp. 93–95) grants that this interpretation does explain things like length contraction and he shows very clearly how. His central objection to the space-time interpretation is that it is incompatible with a preferred frame of reference, which, he claims, is a necessary condition for the existence of God (see conditionals (1)–(4) on p. 173). Such theological considerations lead Craig to embrace the neo-Lorentzian interpretation. We are not theologians and shall not comment on the argument that gets Craig from God to preferred frames of reference. We just want to present what we consider to be a very strong *physical* argument developed by one of us (MJ) for preferring the space-time interpretation over the neo-Lorentzian interpretation. For Craig, presumably, anything short of an a priori argument for this preference would be outweighed by his theological argument. Alas, we only have an inductive argument to offer, albeit it one of the potent common-cause variety. Craig is not alone in rejecting the conclusion of this argument. He quotes several philosophers of quantum mechanics, John Bell and James Cushing among them (Craig 2001a, pp. 226ff), who have argued that the interpretational difficulties with quantum mechanics may call for a neo-Lorentzian interpretation of SR.[17] Before we can present our counter-argument, we need to get clear on what exactly the neo-Lorentzian interpretation involves.

9 The Neo-Lorentzian Interpretation: At What Price?

Following Zahar (1973), Craig (p. 14) bases his discussion of the neo-Lorentzian interpretation on the so-called "doubly-amended theory," a simplified model of Lorentz's mature theory due to Grünbaum (1973, p. 723). The doubly-amended theory consists of the core of Lorentz's theory—Newtonian mechanics and (Lorentz's version of) Maxwellian electrodynamics—plus two special assumptions, the contraction hypothesis and the clock retardation hypothesis. Grünbaum introduced this toy-model to show that these two hypotheses can be added to the core of Lorentz's theory without rendering the theory non-falsifiable. The model is perfectly adequate for this purpose, but it is woefully inadequate for Craig's more ambitious goals.

The problem is that it takes a good deal more than Grünbaum's two amendments to turn Lorentz's core theory into a theory that provides an empirically adequate model of a world in

[17] It has become common wisdom that there is a tension between SR and quantum mechanics. The tension is revealed in the problem of providing a relativistically-invariant account of state vector collapse (Copenhagen, GRW) or of the dynamics of value states in no-collapse approaches (modal interpretation, Bohmian theory). Craig is right to put his finger on these difficulties. But it would be premature to see in this enduring state of perplexity a "way in which quantum physics serves to disclose a privileged reference frame and absolute simultaneity" (p. 223). There is an ongoing debate and no agreed-upon approach to the resolution of the conflict has emerged. The majority opinion, however, appears to be that quantum mechanics will have to give in this case, not SR.

accordance with the postulates of SR. We cannot even derive the Lorentz transformation equations for the space and time coordinates from the doubly-amended theory alone. We need to add the Einstein-Poincaré synchronization convention and this time it is absolutely crucial that the synchronization be done with light signals. As a result of this convention, clocks in a frame in motion with respect to the privileged frame synchronized by a co-moving observer will not read the true time of the privileged frame but the Lorentz-transformed time of the moving frame.

The Einstein-Poincaré convention is an odd one to adopt in the doubly-amended theory. The theory predicts that if the light signals were replaced by bullets, clocks would be synchronized according to the true time. After all, according to Newtonian kinematics, which is part of the doubly-amended theory, a bullet moving from clock *A* to clock *B* will have the same velocity as one moving from *B* to *A* in the frame in which both the two clocks and the two guns used to fire the bullets are at rest. Light, however, only has the same velocity *c* in all directions in the privileged frame. (The theory's two amendments only ensure that the measured two-way velocity of light is *c* in all directions in all inertial frames.) Why would a proponent of the doubly-amended theory prefer the light-signaling method that does not synchronize clocks according to the true time over the bullet-signaling method that does, at least according to his own theory? The only justification we can think of is to invoke effective Lorentz invariance. But is not the goal of this whole enterprise to argue that one can make Lorentz's core theory compatible with SR (i.e., that we can render it effectively Lorentz invariant) by adding just a few extra assumptions? If effective Lorentz invariance is simply going to be assumed at some point in this operation, we might as well assume it right from the start, in which case there is no need for Grünbaum's two special amendments either.

We reiterate that the empirical viability of the neo-Lorentzian interpretation hinges on its ability to provide a concrete model of a world in accordance with Einstein's two postulates. In such a world, the results of the bullet-signaling synchronization procedure will agree with those of the light-signaling procedure. So not only does the proponent of the doubly-amended theory have no justification for his synchronization convention; his theory, as it stands, is simply not viable empirically. What is needed is a third amendment, and then some.

The Lorentz transformation equations for the space and time coordinates encode three deviations from the Galilean transformation equations: relativity of simultaneity, length contraction, and time dilation. In order to account for the last two effects, Grünbaum's two amendments were added to Lorentz's core theory as exceptions to the rule that the spatio-temporal behavior of all systems is the standard spatio-temporal behavior of Newtonian kinematics. The third amendment decrees a similar exception to account for the first effect. The Newtonian norm is that, in any inertial frame, two events that occur simultaneously in different parts of some physical system at rest also occur simultaneously when that same system is in uniform motion. The third amendment to Lorentz's core theory says that, contrary to this Newtonian norm (but in accordance with the relativistic norm), two events occurring simultaneously in different parts of a system at rest in the privileged frame will occur one after the other if the same system is moving with respect to the privileged frame, the event occurring closest to the rear end of the moving system occurring first. Unless one simply invokes effective Lorentz invariance, which seems to defeat the purpose of the whole game, the third amendment sounds far more outlandish than either the length contraction or the clock retardation hypothesis. Once accepted, however, it does provide a rationale for the Einstein-Poincaré convention for clock synchronization. It also guarantees that the bullet-signaling method for clock synchronization gives the same results as the light-signaling method.

The now triply-amended theory, however, is still not compatible with SR. The three amendments only guarantee that proponents of the two theories will agree upon the basic transformation equations for the space and time coordinates. To prove compatibility it must be shown that the triply-amended theory "only allows systems and processes described in terms of such coordinates that also are allowed by SR" (Janssen 2002). To achieve this, it must be assumed that the laws effectively governing all physical systems are Lorentz invariant.[18] Needless to say, the contraction hypothesis and the clock retardation hypothesis are Mickey Mouse compared to this broad assumption of effective Lorentz invariance. Craig's substitution of the toy-model for the theory itself suggests that the contraction hypothesis and clock retardation hypothesis are all it takes to produce a neo-Lorentzian interpretation of SR. It actually takes a lot more.

We should emphasize that the problems discussed above are problems for the doubly-amended theory, the toy-model of Lorentz's theory, not for the theory that Lorentz (1915) himself held. Not that this will be of any comfort to Craig: we shall see that a neo-Lorentzian interpretation along the lines of Lorentz's actual theory still faces debilitating problems. To bring out those problems we need a more accurate model of Lorentz's theory.[19] In modern terms (and glossing

[18] On the face of it, there appears to be another way to achieve compatibility with SR in one fell swoop. One could add a fourth amendment to the effect that all physical observations can ultimately be reduced to observations of positions and times. To justify that amendment one could cite the famous "point-coincidence argument" (Einstein 1916, p. 117). Even so, one would presumably want to add more theoretical structure. Trying to rewrite all statements of the quadruply-amended theory in terms of statements about space-time coincidences comes dangerously close to replacing that theory by its "Craig-system" or its "Ramsey-sentence," a strategy known to be fatally flawed (Hempel 1965, sec. 9). Einstein, of course, never intended to use the point-coincidence argument in this manner. Even on a naïve positivistic reading (see, however, Howard 1999), the argument only states that the empirical content of the theory is exhausted by the set of point coincidences. That does not prohibit one from introducing additional theoretical structure. But if one allows extra theoretical structure in the quadruply-amended theory, one would have to trade in all Galilean-invariant structure of Lorentz's core theory for Lorentz-invariant structures of SR in its four-dimensional formulation. E.g., Lorentz, in effect, replaced classical mechanics by relativistic mechanics in his theory. So, this approach eventually just leads us back to the assumption of effective Lorentz invariance.

[19] One of us (MJ) has developed such a model in detail in several places (see Janssen 1995, 2002; Janssen and Stachel, forthcoming). This work was begun under supervision of Lorentz expert A.J. Kox, whose name is spelled 'Knox' in Craig's book, an unfortunate slip for a book dedicated to Lorentz (and to three neo-Lorentzians).

over details irrelevant to the present discussion), Lorentz could prove the Lorentz invariance of the free Maxwell equations and realized that he could use this result (called the 'theorem of corresponding states') to predict negative outcomes in a broad class of experiments aimed at detecting the earth's motion through the ether by adopting a far-reaching generalization of the physical hypothesis he had originally introduced to account for the Michelson-Morley experiment. In modern terms, this bold new hypothesis (dubbed the 'generalized contraction hypothesis' in Janssen 1995) states that the laws effectively governing all forms of matter are Lorentz invariant, just as the equations governing the fields interacting with it are. This hypothesis entails the amendments of the triply-amended theory, the relativistic velocity dependence of inertia, and much more. Yet, as bold as it is, Lorentz's theory provided a good rationale for adopting the generalized contraction hypothesis. And since the hypothesis trivially renders the theory effectively Lorentz invariant, it does provide a basis for an *empirically viable* neo-Lorentzian interpretation of SR. The explanatory deficiencies of such an interpretation, however, are staggering.

10 The Neo-Lorentzian Interpretation: With What Payoff?

Craig seems to imply that when it comes to explanatory power, there is essentially a tie between the neo-Lorentzian interpretation and the space-time interpretation. In this he is mistaken in our view, although several quotations in his book make it clear that it is a common mistake. We are certainly not the first ones to correct it. In fact, Craig (p. 99) quotes a passage in which Grünbaum clearly explains the nature of the mistake. The point, however, bears repeating.

What is there to explain about phenomena such as length contraction and time dilation? Using the notion of "contrast classes" (van Fraassen 1980, sec. 2.8), we can formulate the why-question that we suspect lies behind the demand for an explanation: why is a rod in motion shorter than a rod at rest *rather than equally long*? For those who share the Newtonian presupposition implicit in this why-question, the neo-Lorentzian interpretation provides a very satisfactory answer to this question. Contrary to what one would expect in Newtonian theory, the forces holding the rod together are not Galilean invariant but Lorentz invariant. As a consequence the equilibrium state of a rod in motion with respect to the privileged frame is shorter than the equilibrium state of a rod at rest. For co-moving observers, however, it will *appear* to be the other way around since their clocks will not read the true time of the privileged frame but the Lorentz-transformed time of the moving frame (Dorling 1968). For those who do not share the Newtonian presupposition of the why-question, this answer completely misses the mark. Instead, such a person would simply point out that the presupposition is wrong. There is no *a priori* reason to think that space and time will be Newtonian. In fact, the universality of the behavior of the rod (i.e., any physical system whatsoever will exhibit the exact same contraction) suggests that space and time are Minkowskian. Length contraction is part of the normal spatio-temporal behavior of systems in Minkowski space-time. There is nothing further to explain.

An example from ordinary three-dimensional geometry may help here. Suppose one night Roxanne comes down from her balcony and spots Cyrano. As Cyrano turns around to run off, Roxanne sees his nose, protruding from his silhouette against the night sky, become more and more pronounced until eventually she sees it get smaller and smaller again and vanish. This behavior of Cyrano's nose is part of the normal spatial behavior of objects in three-dimensional Euclidean space and does not seem to call for any further explanation—the demand for an explanation would only arise if the length of the nose of the silhouette did *not* change! Now it is true that for Cyrano's nose to behave the way it does, it is necessary that the forces holding it together are invariant under spatial rotation. The question is what explains what. Does the Euclidean nature of space explain why the forces holding Cyrano's nose together are invariant under rotation or the other way around? Likewise, does the Minkowskian nature of space-time explain why the forces holding a rod together are Lorentz invariant or the other way around? Our intuition is that the geometrical structure of space(-time) is the *explanans* here and the invariance of the forces the *explanandum*. To switch things around, our intuition tells us, is putting the cart before the horse. Some readers may not share this intuition.[20] We ask such readers to read on.

11 Why We Should Prefer the Space-Time Interpretation over the Neo-Lorentzian Interpretation

There is a better way, we think, for arguing for the explanatory advantage of the space-time interpretation over the neo-Lorentzian interpretation (Janssen 1995, 2002). Compare the status of Lorentz invariance in the two interpretations. In the former, Lorentz invariance reflects the structure of the space-time posited by the theory. In the latter, Lorentz invariance is a property accidentally shared by all laws effectively governing systems in Newtonian space and time. As a result, the neo-Lorentzian interpretation violates the symmetry principles of Earman (1989, p. 46), which state that every symmetry of the space-time posited by a theory should be a symmetry of that theory's dynamical laws and vice versa. These principles are called 'SP1' and 'SP2', respectively. Galilean transformations correspond to symmetries of the space-time posited by the neo-Lorentzian interpretation, but not to symmetries of the theory's dynamical laws (i.e., SP1

[20] E.g., Dieks 1984, quoted by Craig (p. 100), seems to be based on the opposite intuition. We suspect that many relationists share Dieks's intuition. Since the invariance group (Lorentzian or Galilean) of the dynamical laws essentially *is* the space-time structure for a relationist, the (effective) Lorentz invariance of the dynamical laws in a sense does seem to explain for a relationist why the (effective) space-time structure is Minkowskian. Such an explanation, of course, does not amount to an explanation of why the space-time structure is Minkowskian *rather than Newtonian*, unless the relationist has some *a priori* reason to expect the structure of space and time to be Newtonian. It also does not interchange the roles of *explanans* and *explanandum* in our Cyrano-and-Roxanne example. The behavior of Cyrano's nose is just an instance of the normal spatio-temporal behavior of objects in Minkowski space-time, no matter whether one is a substantivalist or a relationist about the ontology of space(-time). The explanatory considerations in the text are therefore largely independent of one's stance on the ontology of space(-time).

fails). Lorentz transformations correspond to symmetries of the dynamical laws in the neo-Lorentzian interpretation, but not to symmetries of its space-time (i.e., SP2 fails). Earman's justification for these principles is that they "provide standards for judging when the laws and the space-time structure are appropriate to one another" (Earman 1989, p. 46). What happens when they are not, especially when there is a competing theory in which they are?

This is where the argument we alluded to above comes in.[21] In the neo-Lorentzian interpretation it is, in the final analysis, an unexplained coincidence that the laws effectively governing different sorts of matter all share the property of Lorentz invariance, which originally appeared to be nothing but a peculiarity of the laws governing electromagnetic fields. In the space-time interpretation this coincidence is explained by tracing the Lorentz invariance of all these different laws to a common origin: the space-time structure posited in this interpretation (Janssen 1995, 2002).[22]

The argument can be made in different ways. Einstein made it in the opening paragraph of the 1905 paper with the help of his famous magnet-conductor example: for the current measured in the conductor only the relative motion of magnet and conductor matters, but in Lorentz's theory the case with the magnet at rest is very different from the case with the conductor at rest. No matter how the argument is made, the point is that there are brute facts in the neo-Lorentzian interpretation that are explained in the space-time interpretation. As Craig (p. 101) writes (in a different context): "if what is simply a brute fact in one theory can be given an explanation in another theory, then we have an increase in intelligibility that counts in favor of the second theory." We just presented such an argument in the case of the space-time interpretation versus

[21] The argument was inspired by the reconstruction of Perrin's argument for molecular reality as a common-cause argument in Salmon 1984, pp. 213–221.

the neo-Lorentzian interpretation. The argument is not iron-clad and may still be outweighed by the needs of theology or quantum mechanics. But it is on a par with, say, the argument for preferring Darwinian evolution over special creation. That is good enough for us.

12 What About General Relativity?

Does the A-theory fare any better in general relativity (GR)? Like other A-theorists, Craig argues that the cosmological time of some relativistic models of the universe can be used to support the tensed theory. Apart from the fact that the connection between the absolute time of neo-Lorentzian theories and the cosmic time is unclear, the notion of the latter itself is not robust enough to identify it (as Craig does) with "metaphysical time" appropriate for presentism. First, the uniform cosmic time is a feature only of idealized (homogeneous and isotropic) cosmological models. Second, the notion of cosmic time originates, not from the nomological framework of GR, but from the contingent boundary conditions imposed on it. Finally, before one obtains such a notion, one still starts with the four-dimensional space-time manifold, whose essential role is hard to square with the ontological requirements of presentism.[23] It is true that, mainly as a result of recent work on the so-called "hole argument" (see, e.g., Earman 1989, Ch. 9), the ontological status of the manifold in GR has been called into question. The hole argument seems to suggest that the manifold is not a substance, but should be thought of in relational terms. We shall not pursue the possible ramifications of these developments for the issues under discussion here. General relativistic space-time is a complex subject and Craig invokes it only briefly. We therefore restrict ourselves to these brief remarks.

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[22] This is a version of the type of "no conspiracy"- argument captured in Einstein's aphorism "Subtle is the Lord, but malicious he is not" briefly discussed by Craig (p. 184). By using the doubly-amended theory as his model for the neo-Lorentzian interpretation, Craig misses the full force of this argument.

[23] Some work has been done on "3+1"-formulations of general relativity, in particular by Barbour and Bertotti (see Barbour 1999 for references), but mainstream general relativists continue to use the four-dimensional formulation.

13 Squaring the Tenseless Space-Time Interpretation With Our Tensed Experience

We have argued that relativity theory—and the *physical* evidence supporting it—point strongly in the direction of the tenseless B-theory of time. Metaphysicians of time sensitive to scientific evidence thus have their work cut out for them. We suspect that, when pressed on the issue, the average physicist will do no better than Hermann Weyl in trying to reconcile the tenseless world of relativity with our tensed experience: "The objective world simply *is*, it does not *happen*. Only to the gaze of my consciousness, crawling upward along the life line of my body, does a section of this world come to life as a fleeting image in space which continuously changes in time" (Weyl 1949, p. 116[24]; cf. Weyl 1922, p. 217). Einstein may have articulated the poor man's view on these matters best when he wrote three weeks before his death (Fölsing 1997, p. 741): "To us believing physicists the distinction between past, present, and future has only the significance of a stubborn illusion."

As we hope to have shown, Craig fails completely in his attempt to make the case that we should trade in the standard space-time interpretation of SR for the neo-Lorentzian interpretation, but his work on the metaphysics of time forcefully reminds us of the challenge to improve on Weyl's account of the "stubborn illusion" referred to by Einstein.

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[24] For Craig’s comments on this passage, see his 2000a, p. 219, note 7.

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