Presentism in a World Denied Instantaneous Signals[1]

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The special theory of relativity (STR) is widely regarded as the primary threat to the otherwise intuitive presentist worldview. In particular, both the relativity and conventionality of simultaneity within STR appear to undermine presentism and support eternalism. However, the single term 'simultaneity' describes multiple potentially independent concepts. By establishing the mutual independence of the relevant concepts of simultaneity, the presentist and eternalist may agree to move past the initial threat to presentism posed by STR. The subsequent debate hinges on whether presentism or eternalism best accounts for the principle of relativity. The presentist is often accused of initially failing to identify the absolute present and then constructing a model that hides it using an unlikely set of premises. As a result, the eternalist Minkowski space-time interpretation appears simpler in many respects. However, it is demonstrated that on presentism one may obtain the principle of relativity by simply prohibiting instantaneous signals between distant events. Many of the objections against the presentist Neo-Lorentzian interpretation of STR are answered in light of this demonstration. The partition between the experimental evidence provided by STR and human experience is found to be unnecessary.

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1 Introduction

At first glance, the world appears to be three-dimensional since self-consciousness is limited to the present moment. Natural emotional responses to past, present, and future events generally differ.[2] Putnam suggests that the man on the street regards his experience as evidence for presentism ([1967]), the view that only the present exists.[3] Indeed, Scherr et al. find that physics students generally maintain their belief in absolute simultaneity despite instruction to the contrary ([2001], [2002]). Of course, personal experience is not infallible. Given decisive evidence, one ought to part with false conclusions based on illusory sense perceptions.[4] For many, the special theory of relativity (STR) provides sufficient grounds to justify abandoning presentism in favour of eternalism, the view that the past, present, and future enjoy equal ontological status.

For example, Putnam ([1967]) and Weingard ([1972]) have argued, respectively, that the relativity and conventionality of simultaneity each entail eternalism over presentism. These two classic arguments are examined in Section 2 and are shown to

[2] For a review of these first impressions, see for example (Craig [2001], pp. 129-144).

[3] Specifically, Putnam writes that 'All (and only) things that exist now are real. Future things (which do not already exist) are not real (on this view); although, of course they will be real when the appropriate time has come to be the present time. Similarly, past things (which have ceased to exist) are not real, although they were real in the past'([1967]).

[4] Craig argues that the reality of temporal becoming is a properly basic belief potentially strong enough to serve as an intrinsic defeater-defeater ([2001], p. 143).

hinge on a dubious identification of three feasibly independent concepts of simultaneity. In fact, the absolute present must be independent of any (relative or conventional) present proposed by STR, either by virtue of its non-existence or its invisibility. The subsequent debate hinges on whether presentism or eternalism best accounts for the principle of relativity, namely the concealed nature of the absolute present.

Naturally, the eternalist requires the presentist to account for the hidden nature of the absolute present, an entity that simply does not exist on eternalism. For example, Balashov and Janssen ([2003]) contrast the apparent complexity of Craig's presentist interpretation of STR with the apparent simplicity of the eternalist Minkowski space-time interpretation. Generally speaking, the presentist stands accused of relying on too many physical postulates to support a presentist worldview, an intellectual price that need not be paid by the eternalist.

This eternalist challenge is addressed in Section 3. Beginning merely with a prohibition against instantaneous distant signalling in absolute space, and clarifying the epistemic content of observation, the presentist may obtain a constructive theory that accounts for the principle of relativity and its wide application to all classical field theories potentially identified with conservation laws. In Section 4, Craig's presentist Neo-Lorentzian interpretation of STR is placed within the constructive theory of Section 3. This provides that interpretation with feasible postulates and answers the criticism that STR is more than just an electromagnetic theory.

Lastly, the eternalist tends to assign the burden of proof to the presentist by erecting a partition between experimental evidence (provided by STR) and human experience. This partition is briefly examined in Section 5 and shown to be unnecessary given that STR clearly fails to rule between presentism and eternalism. Therefore, human experience cannot be easily dismissed on the basis of STR. Although the initial sense perceptions of the man on the street are partially illusory, the existence of a doubly hidden absolute present remains both a rational and useful inference.

2 The Relativity and Conventionality of Simultaneity

2.1 Two Classic Arguments from STR

The first major argument against presentism, driven by the authority of STR, is the argument from the relativity of simultaneity raised by Putnam ([1967]). This approach is summarized in (Savitt [2000]; Bourne [2004]; Craig [2008], Callender [2008]), to name a few. Interestingly, students at all levels are initially unconvinced by this argument and tend to instead form an erroneous 'conceptual framework in which the ideas of absolute simultaneity and the relativity of simultaneity co-exist'(Scherr et al. [2001], [2002]). I provide an abridged summary of the argument below, supposing throughout that observer A exists presently:

(1) Only the present exists.

(2) B exists if and only if A and B are simultaneous.

(3) Simultaneity is relative to an observer's motion.

(4) B's existence depends on the motion of A.

Premise (1) is a simple summary of the presentist worldview. Premise (2) provides the term 'simultaneous' with the metaphysical content of mutual present existence. As defined, the conjunction of (1) and (2) requires that the present contain a set of simultaneous events. By identifying 'simultaneity' in (3) with 'simultaneous' in (2), one must choose between keeping (1) and eliminating (4). A Minkowski space-time diagram often accompanies this argument.[5] If the space and time axes are held orthogonal (in Minkowski space-time[6]), then observer A's velocity determines the orientation of both the time and space axes. B only exists on A's spatial axis for a specific A velocity. If the present is identified with the orthogonal spatial coordinate axes, then present existence clearly depends on observer motion.

The second argument against presentism driven by the authority of STR is based on the conventionality of simultaneity. First raised by Weingard ([1972]) and also presented by Petkov ([1989]), this argument is similar to the previous one, substituting (3) and (4) with the following additional propositions:

(5) Distant simultaneity is a matter of convention.

(6) If B is distant from A, then the existence of B is a matter of convention.

Proposition (5) is motivated by the impossible task of measuring the one-way speed of light without first choosing a coordinate synchronization scheme. See for example (Winnie [1970a], [1970b]; Petkov [1989]; Sonego and Pin [2009]). If the 'simultaneous' of (2) is the same as the 'simultaneity' of (5), then (6) follows logically from (1), (2), and (5). The presentist must abandon (1) or concede the truth of (6).

The two arguments presented above have many variations, which generally aim to prove the absurdity of presentism by compelling the presentist to either reject presentism or accept that the existence of distant reality is observer dependent. However, the term 'simultaneous' has been used above to represent three potentially independent concepts. Indeed, STR already maintains that the 'simultaneity' of (3) is distinct from the

[5] See for example Figure 2.1 in (Callender [2008]).

[6] On a Minkowski space-time diagram, orthogonal axes are only drawn at 90-degrees if they represent current frame of reference. Otherwise, they are drawn at an acute angle bisected by the 45-degree speed of light line.

‘simultaneity’ of (5). Therefore, at best only one of the two arguments can go through. If these three concepts are indeed independent, then the logical connections between premises (2), (3), and (5) are severed. These three concepts are outlined below.

2.2 A Shared Conclusion

First, ‘standard simultaneity’ (SS) is a well-defined relation within STR. Malament ([1977]) has proven that Minkowski space-time provides a unique synchronization of distant clocks: orthogonal four-dimensional coordinates with the time axis tangential to the observer’s worldline. The concept of orthogonal coordinates requires the use of a diagonal metric, which Minkowski space-time supplies. Both the Einstein synchronization convention and slow clock transport produce standard simultaneity relations (Mansouri and Sexl [1977]). Any synchronization method leading to standard simultaneity may be referred to as ‘internal synchronization of clocks’ (Mansouri and Sexl [1977]). The term ‘relativity of simultaneity’ refers to the fact that observer motion determines which distant events stand in a standard simultaneity relation with respect to the observer.

Secondly, ‘coordinate simultaneity’ (CS) is a coordinate dependent relation between events on a four-dimensional manifold. If two events share the same time coordinate value in a given coordinate system, then they are coordinate-simultaneous with respect to that coordinate system. Standard simultaneity is simply coordinate simultaneity with the addition requirement that the coordinates are orthogonal according to the Minkowski metric. Through an ‘external synchronization of clocks’ one observer may adopt the coordinate simultaneity of another observer in relative motion, although this will inevitably lead to non-orthogonal coordinates (Mansouri and Sexl [1977]). The freedom to use either orthogonal or non-orthogonal coordinates is commonly referred to as the 'conventionality of simultaneity'.[7]

Thirdly, 'absolute simultaneity' (AS), is the presentist metaphysical relation between two existing events. In principle, one could design a coordinate system in which coordinate and absolute simultaneity coincide.[8] Indeed, if an observer were at absolute rest, standard simultaneity would coincide with absolute simultaneity. The validity of presentism is tied to the existence of the absolute simultaneity relation.

For the purposes of this discussion, a frame of reference for a given observer is a special coordinate system in which the spatial location of the observer is regarded as a constant. A frame of reference may use either SS or CS coordinates depending on whether the coordinate system is orthogonal relative to the Minkowski metric. Naturally, if an observer is in absolute motion, SS and AS relations will not coincide. However, the observer is still free to choose a coordinate system in which CS and AS relations coincide through an external synchronization of clocks.

In light of this classification of concepts, we may amend (2), (3), and (5) as follows:

(2') B exists if and only if A and B are absolutely simultaneous.

(3') Standard simultaneity is relative to an observer's motion.

(5') Distant coordinate simultaneity is a matter of convention.

Premises (1), (2'), and (3') do not imply (4) unless absolute simultaneity is identified with standard simultaneity. Premises (1), (2'), and (5') do not imply (6) unless absolute

[7] The conventionality of simultaneity has been heavily debated, with (Malament [1977]) playing a key role. See also (Grünbaum [2010]). For the purpose of this paper, conventionality simply refers to freedom to use non-orthogonal coordinates.

[8] Namely, the entire present consisting of all existing events may be indexed by three linearly independent variables. A fourth variable would be used to denote time as the absolute present evolves.

simultaneity is identified with coordinate simultaneity. Therefore, to avoid (4) and (6), an undesirable observer-dependent reality, the presentist and eternalist may agree that:

> (7) If absolute simultaneity relations exist, then they are independent of both standard and coordinate simultaneity relations.

Note that STR does not forbid SS and CS relations from coinciding within a given frame of reference. Similarly, (7) does not forbid AS relations from coinciding with a particular choice of CS or SS relations. Independence simply ensures that the coincidence represents a special case rather than a fundamental connection between concepts.[9] Although the presentist and eternalist are opposed concerning (1), they must agree about (7).

3 A Presentist Interpretation of STR

Having identified the common ground shared by the presentist and eternalist, the debate shifts towards who can best explain the principle of relativity. The task for the presentist is to either identify the absolute present or clearly demonstrate why that task is impossible. The eternalist argues that it is impossible to identify the absolute present within STR simply because it doesn't exist; all events are equally real. Relativistic phenomena such as length contraction and clock retardation are regarded as best explained by the structure of an existing four-dimensional Minkowski space-time (Balashov and Janssen [2003]; Petkov [2007], Norton [2008]). Furthermore, the success of modern relativistic field theory developed within Minkowski space-time seems to justify the eternalist position. On the other hand, the presentist seems compelled to hold

[9] In this paper I am interested in whether such a special case could plausibly exist. I therefore limit the discussion to 'surface' presentism. Hinchliff ([2000]) notes that the presentist may adopt a point, cone, or surface model of the present. The other options for the presentist are much less appealing. The point model fails to explain the supposed existence of distant reality. The cone model has some bizarre properties, such as regarding the emission of the cosmic microwave background radiation in the early universe as simultaneous with modern observers (Savitt [2000]).

that the absolute present is hidden from observation due to the electromagnetic physical effects of Lorentz contraction and clock retardation. As a result, presentism stands accused of postulating the Lorentz covariance of all physical field theories *ad hoc* in order to hide the absolute present from the observer (Balashov and Janssen [2003]). Indeed, many presentists feel compelled to look outside of STR at quantum mechanical or general relativistic arguments for the existence of the absolute present (Bourne [2004]; Callender [2008]). Nonetheless, there remain good reasons to infer the existence of an unobservable distant absolute present within STR.

3.1 Theories of Principle and Constructive Theories

Balashov and Janssen ([2003]) hold that if STR is regarded strictly as a theory of principle, then it does not reveal the ontology of space and time. Rather, if certain postulates hold true in a given world, then their implications will also hold true in that world. As a theory of principle, STR rests on two postulates:

(8) There are no (ontologically) preferred inertial observers.[10]

(9) The speed of light is isotropic and independent of both observer and source motion.[11]

Of course, these postulates are not conversely proven by the verification of their experimental implications. Constructive theories of relativity,[12] however, may be built upon various three-dimensional presentist or four-dimensional eternalist ontologies, provided that the model proposed explains the relevant experimental evidence (Balashov

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[10] There are a variety of ways to express this principle. For the eternalist, no preferred observer exists since no absolute space exists to pick out a single ignorant preferred observer; there are no ontologically preferred inertial observers. Generally, the presentist would state that no preferred observer has objective knowledge of being at rest in absolute space; there are no epistemically preferred inertial observers.

[11] This postulate is often misunderstood. For clarification, see (Baierlein [2006]).

[12] The term 'constructive theory' is used here in the sense described by Balashov and Janssen ([2003]) and not in the sense described by Norton ([2008]). The debate between presentism and eternalism addressed here is not simply a debate between the relational and substantival positions.

and Janssen [2003]). One such presentist theory, the Neo-Lorentzian interpretation (Craig [2008]), is often criticized on two counts. First, Balashov and Janssen regard the theory as 'triply-amended' ([2003]), requiring too many postulates and resulting in too few useful implications. As a result, the principle of relativity is implicitly postulated rather than explained (Norton [2008]). Secondly, the Neo-Lorentzian interpretation appears to say little about non-electromagnetic phenomena, thereby ceding credibility to Minkowski space-time as a common origin for all relativistic effects (Balashov and Janssen [2003]; Norton [2008]). It seems that the task of the presentist is to build a constructive model that explains, rather than postulates, both the principle of relativity and its application to non-electromagnetic systems. In what follows, the substantival existence of absolute space is assumed and a prohibition against instant signalling is postulated. The relativity principle, namely the prohibition against detecting motion through absolute space, is shown to follow from these postulates.

3.2 Epistemic Content of Observation

The light speed postulate of STR, represented by premise (9), places firm limits on objective knowledge of the world by denying the observer immediate awareness of distant events. However, the key implications of (9) are not due to the isotropy of the speed of light, or even the agreement between all observers about the one-way speed of light (Sonego and Pin [2009]). Stripping (9) of these requirements, we consider the following revised postulate:

(9') Distant instantaneous physical signalling or communication is prohibited.

Both human experience and experimental evidence confirm this prohibition. The potential exception involves entangled quantum particles. However, it is clear that these theoretically instantaneous signals are of no use for communication (Callender [2008]). As a result, the distant present is effectively invisible. The present is only experienced locally; observations of distant events are always observations of the past. Therefore, only local observations made at one's current location contribute to one's direct knowledge of the absolute present.

What about indirect knowledge? Premise (9') immediately suggests an interesting distinction between perception and observation, first suggested by Terrell ([1959]).[13] The following definitions apply for the purpose of this discussion. A *perception* is the present local awareness of any number of simultaneously received signals, arriving from different directions, with various intensities, and potentially emitted at different times. Each signal conveys information about its source's past, while the presently existing source remains hidden. On the other hand, an *observation* consists of placing perceived data into a three-dimensional model that accounts for the simultaneous emission and original locations of the multiple signals perceived. Signal perception may be considered a local observation of the signal since it is independent of both perceiver motion and coordinate simultaneity.

To illuminate these definitions with an example from STR, consider a photograph taken of an object flying past the photographer at a relativistic speed. Terrell demonstrates that given STR, the Lorentz contraction is invisible to the perceiver, regardless of relative motion of the object and the photographer ([1959]).[14] Of course,

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[13] Terrell ([1959]) differentiates between seeing and observing in terms of simultaneous reception versus simultaneous emission of light signals. The term 'perceive' is intended to extend Terrell's 'seeing' to include non-electromagnetic signals and signals traveling at various speeds.

[14] This result holds over small solid angles. The observer's field of view undergoes a conformal transformation resulting in image magnification proportional to the Doppler shift. Objects appear rotated rather than contracted (Terrell [1959]). Nevertheless, the Lorentz contraction is not strictly perceived.

one may observe the phenomenon by using SS coordinates to calculated the nature of the optical illusion and remove it from the photographs. See for example (Deissler [2005]). However, if CS coordinates are used, a different type of optical illusion will be edited out of the picture.[15] One photograph yields a multitude of observations, each connected to a specific choice of coordinate simultaneity.

In order to form a distant observation without instantaneous signals, a frame of reference is required to classify the information provided by means of perception. Since frame of reference depends on both observer motion and synchrony preference (SS or CS relations), then the invariant component of any observation is the information perceived. An observer is firstly a perceiver. Therefore, it follows from (1) and (9') that:

(10) The epistemic content of observation is limited to local perceptions independent of coordinate simultaneity and observer motion.

We now apply premise (10) to some fairly simple examples. Consider first the one-way velocity of light.[16] Perceiver A is required to record the emission of a light signal at a local time. Distant perceiver B is required to record the arrival of that light signal at a different local time. Both perceptions count as local observations. However, to combine them, the clocks of both perceivers must be synchronized. Therefore the observation of the one-way velocity of light is not directly perceived and cannot become a synchrony-independent law. Interestingly, when discussing light signals, one may not confirm the stronger condition (9) given the truth of the weaker condition (9').

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[15] Terrell's derivation of the invisibility of the Lorentz contraction rests solely on the Lorentz transformation of angular the spatial coordinates ([1959]). Since it does not depend on any specific time transformation, this result also holds for alternate coordinate simultaneities. Therefore, the Lorentz contraction is equally invisible for observers using CS and SS coordinates, in agreement with the conventionality of simultaneity.

[16] There is a great deal of literature on this topic. Some examples advocating the conventionality of simultaneity include (Tangherlini [2009]; Winnie [1970a], [1970b]; Mansouri and Sexl [1977]; Selleri [2005]; Sonego and Pin [2009]; Iyer and Prabhu [2010]; Grünbaum [2010]).

Next, consider the process of counting distant sources. Suppose perceiver A is constantly receiving signals from discrete sources within a region of finite volume. In principle, a qualified perceiver could record the angular position and signal intensity of each incoming signal at the given moment. By producing successive source charts, analogous to star charts, perceiver A could determine that the number of observable sources in the region is fixed. Much like an air traffic controller uses radar to confirm that airborne aircraft are neither created nor destroyed, a suitably equipped perceiver could count the number of perceived particles of a given signal type at any given moment. Subsequently, the perceiver could conclude that these source particles are neither created nor destroyed. If a conservation law for source particles can be perceived as a local observation, then this conservation law is independent of simultaneity conventions.[17]

Alternatively, an experimenter could set up a laboratory suitably equipped with instruments to locally detect the presence of signal sources. In order to record the times and locations of each local detection, the detector locations must be indexed using a laboratory spatial coordinate system. Next, the clocks on each detector, which are presumed to operate identically, must be synchronized in a suitable manner. Clock transport, supposedly isotropic signals, and external clock synchronization are all potential methods. The main criteria for clock synchronization is that the $t = 0$ index moves faster than the sources through the laboratory in absolute space, in order to avoid counting a source twice. At any moment, as defined by coordinate simultaneity criteria, the experimenter could count the number sources detected within the laboratory. Re-

[17] It is assumed that the perceiver is travelling at a velocity suitable for the reception of signals from any angle. This limits the perceiver to velocities less than the signal speed while making accurate perceptions.

synchronizing the detector clocks according to a different CS relation, the experimenter could repeat the counting experiment. Provided that no source is counted twice, and that the sources endure in time, the number of sources detected simultaneously is an invariant property of the system.

In light of these examples, the argument may be expressed as follows. On presentism (1), all that exists forms a three-dimensional manifold Σ_0 evolving through time. Provided that no particle or signal travels at an actually infinite speed (9'), and therefore endures beyond the present moment, then Σ_0 is a Cauchy surface. A Cauchy surface intersects each particle and signal worldline exactly once within the direct product space $\Sigma_0 \times R$. The existence of the single 'Cauchy surface' Σ_0 implies that $\Sigma_0 \times R$ is diffeomorphic to (M, g), a globally hyperbolic (pseudo-Reimannian) metric space (Dieckmann [1988]). When suitably diagonalized, metric g reduces to the Minkowski metric η (Nakahara [2003], p. 245).

In practice, there exist multiple CS schemes where no source or signal is counted twice. Each of these corresponds to a Cauchy surface Σ within the metric space $(\Sigma_0 \times R, g)$. Therefore, each space $\Sigma \times R$ is also diffeomorphic to (M, g). If there are multiple Cauchy surfaces permitted by (M, g), it is unclear which corresponds with absolute space Σ_0. It is clear that the existence of just one Cauchy surface Σ_0 is sufficient to establish that $\Sigma_0 \times R$ is globally hyperbolic and diffeomorphic to (M, g). Therefore, provided that we exclusively use CS coordinates that fit Cauchy surfaces Σ, then:

(11) Particle conservation laws are perceivable, independent of both observer motion and coordinate simultaneity convention.

To summarize, we may begin with presentism (1) and a prohibition against instantaneous signalling (9') and conclude that the epistemic content of observation is limited to local perceptions (10). Any one-way non-zero velocity is not strictly perceivable, illustrating the conventionality of (9). On the other hand, particle conservation laws are in principle perceivable and may be described using a wide range of suitable coordinate systems (11). Therefore,

(12) Conservation laws obey the epistemic principle of relativity. One may not use conservation laws to detect absolute motion.

3.3 Presentist Covariant Field Theory

If conservation laws obey the principle of relativity, then the field theories associated with each conservation law must also obey the principle of relativity. To demonstrate this, one must consider the standard variational approach used to model physical fields. Mills ([1989]) provides an excellent overview. At the fundamental level, a physical system may be described using a Lagrangian density functional of both dependent and independent variables. Independent variables consist of the space and time coordinates. Dependent variables consist of various functions of space and time, namely the fields.[18] The action is the integral of the Lagrangian with respect to the independent variables over some specified range of their values. Physical laws are generally[19] taken to be configurations of the fields that leave the action unchanged under slight variations (adjustments) of the fields, the space-time coordinates, or the region of integration.

[18] As a result, the Lagrangian may not explicitly contain independent variables yet still implicitly depend on space and time coordinates through space and time dependencies of the field functions.
[19] This requires the application of Hamilton's principle. See (Mills [1989]; Brown and Holland [2004]).

For any given field theory, one may obtain the conservation laws for energy and momentum by holding the action constant with respect to either small variations of the boundaries of the region of integration (Barut [1980], pp. 103-105,115) or small variations of the metric on a general four-dimensional manifold described by the independent variables (Nakahara [2003], pp. 298-300). Put simply, energy and momentum conservation laws follow from one's freedom to use alternative coordinate systems to describe the evolution of a physical system (Mills [1989]). On the other hand, the field equations that govern the physical fields are obtained by holding the action constant while varying the dependent variables, or fields (Barut [1980], pp. 99-103). In general, the mathematical identity known as Noether's theorem correlates field theories with conservation laws. See for example (Plybon [1971]; Al-Kuwari and Taha [1991]; Brown and Holland [2004]).

The distinction between variations of the fields and variations of the coordinates is critical to the present discussion.[20] Variations of the fields that leave the Lagrangian unchanged correspond to both the field equations and the conserved field sources. These variations are often referred to as internal symmetries or gauge symmetry groups (Mills [1989]). By comparison, variations of the coordinate system correspond to the conservation laws of energy and momentum. Surprisingly, the Lorentz transformations of STR do not play a necessary role in either type of variation. First, the symmetry group formed by the Lorentz transformations is independent of the 'internal symmetries'

[20] See Table I in (Barut [1980], p. 102) for several examples of field equations due to the variation of the Lagrangian with respect to the fields. Also see Table II in (Barut [1980], p. 117) for examples of both conserved sources and energy and momentum conservation due to variations of the action with respect to the fields and the coordinate respectively.

represented by the gauge transformation groups governing each field theory.[21] Secondly, the Lorentz transformations are simply a single case of the generalized coordinate transformation that corresponds to energy and momentum conservation. Multiple symmetries can lead to the same conserved quantities. In the case of internal symmetries, both global and local continuous symmetries lead to the same conserved values (Al-Kuwari and Taha [1991]). Similarly, energy and momentum conservation is correlated with invariance of the action under general continuous coordinate transformations (Barut [1980], pp. 108; Nakahara [2003], pp. 298-300). The Lorentz transformations represent a specific case; they are sufficient but not necessary for energy and momentum conservation laws. Therefore, the claim of Balashov and Janssen ([2003]) that reality only corresponds to concepts that are invariant under Lorentz group of transformations is unjustified. The Lorentz group does not uniquely define energy and momentum conservation and is independent of the relevant gauge transformation groups. Rather, one may conclude that:

(13) Energy and momentum conservation laws correspond to the freedom to describe a system using alternate coordinate systems.

(14) Fields equations and conserved field sources correspond to the freedom to describe the fields using different gauges.

The task of the physicist is often to choose the correct Lagrangian[22] to describe any system under consideration. Given a Lagrangian, the physical laws governing energy and momentum conservation, conserved currents, and the distribution of the fields follow naturally from the variational principle. Experiment is required to determine which field theory corresponds to which conservation law. Since conservation laws obey the

[21] Gauge symmetry groups U(1), SU(2), and SU(3) exist independently of the Lorentz transformations.
[22] Two Lagrangians will yield the same physical laws if their difference is simply a gradient with respect to the independent variables (Barut [1980], p. 101; Brown and Holland [2004]).

principle of relativity (12), it follows that the field theory corresponding to a given conservation law may be constructed in any coordinate system in which the conservation law holds, not solely frames of reference connected by Lorentz transformations. Therefore, it follows from (12), (13), and (14) that:

(15) If a conservation law obeys the principle of relativity, then the corresponding field theory obeys the principle of relativity.

In light of this argument, it is clear that the presentist is not obligated to detect the present since the present is doubly hidden by the finite signal speed restriction (9'). First, the finite signal speed forbids perception of distant present events. Second, the inference of the number of presently existing sources from the number of perceived signals received implies that the conservation laws governing the sources are coordinate frame independent. Using variational calculus, Noether's theorem, and experiment, a field theory may be assigned to each conservation law, regardless of coordinate choice. As a result, the observer will not observe any deviations from the expected absolute frame field theory in a moving frame of reference. Therefore, given presentism (1) and the prohibition against instantaneous signals (9'), it follows that:

(8') There are no (epistemically) preferred inertial observers.

4 Objections Towards the Neo-Lorentzian Interpretation

Balashov and Janssen ([2003]) raise at least two major objections against the presentist Neo-Lorentzian interpretation of STR, both of which relate to the principle of relativity. First, the presentist relies on too many postulates to obtain the Lorentz covariance of electromagnetic phenomena. Secondly, the presentist fails to explain the Lorentz covariance of non-electromagnetic phenomena. One may answer both objections by placing the Neo-Lorentzian interpretation within the model presented in Section 3.

Concerning the second objection, the constructive field theory developed above may be considered a generalized version of the electromagnetic Neo-Lorentzian interpretation criticized by Balashov and Janssen in ([2003]). Having perceived conservation of electric charge, one may experimentally rule out all potential Lagrangians furnished by Noether's theorem that do not yield Maxwell's equations and the Lorentz force law. It is clear from the discussion above that any field theory that may be developed using a Lagrangian and the variational approach fits within the presentist worldview. The Neo-Lorentzian interpretation merely considers electromagnetism, an Abelian gauge theory. Non-Abelian gauge theories rely on the same mathematical structure and may in principle be treated in an analogous fashion, without recourse to eternalism.

We now consider the first objection and specifically examine the electromagnetic case. Balashov and Janssen ([2003]) claim that the Neo-Lorentzian theory is 'triply amended' and posits extra unnecessary structure to reality in order to obtain the relativity principle. In particular, they accuse the presentist, specifically the Neo-Lorentzian, of assuming Newtonian mechanics, Maxwell's electrodynamics, Lorentz contraction, clock retardation, standard simultaneity relations, and ultimately the Lorentz covariance of all non-electromagnetic field theories in order to explain the experimental data supporting the principle of relativity ([2003]).

By way of an overall response, it is clear from Section 3 that the Neo-Lorentzian interpretation can be firmly grounded in presentism (1) and the reality of the prohibition against instant signals (9'). The rest is up to experiment to determine whether the conserved charge observed is indeed electric or part of a different field theory. Furthermore, the theory criticized in (Balashov and Janssen [2003]) need not depend on such a wide range of postulates. Concerning the number of postulates, Erlichson ([1973]) provides a historical overview of the postulates and implications of the 'Lorentz Theory A' (LTA), 'Lorentz Theory B' (LTB), and STR. It seems that Balashov and Janssen ([2003]) level their criticism against a combination of LTA and LTB, thereby supposing that the presentist must adopt the postulates of both models. However, the LTA postulates an ether, rod contraction, and clock retardation; it then derives the Lorentz transformations and the relativity principle as a result. The LTB postulates an ether and the covariance of Maxwell's equations; it then derives the Lorentz transformations, rod contraction, and clock retardation (Erlichson [1973]). The presentist isn't committed to assuming the postulates of both the LTA and the LTB. Rather one is free to assume the postulates of the LTA, the LTB, or potentially just (1) and (9'), as discussed above.

Specific responses concerning the use of Newtonian mechanics and standard simultaneity relations are in also order. First, Balashov and Janssen ([2003]) criticize the Neo-Lorentzian interpretation for adopting Newtonian mechanics. Perhaps this objection follows from the false dilemma raised between the Galilean covariance of Newtonian mechanics and the Lorentz covariance of Maxwell's equations. See (Tangherlini [2009]) for a detailed examination of this false dilemma.[23] Since these two symmetry groups differ concerning the relativity of simultaneity (Baierlein [2006]), and the Lorentz group has greater experimental confirmation, one might suppose that simultaneity must be relative. However, the absolute Lorentz transformations (ALT) first developed by Tangherlini ([2009]), and further discussed in (Mansouri and Sexl [1977]; Selleri [2005]; Iyer and Prabhu [2010]), satisfy the experimental data while conserving simultaneity relations. This approach is particularly useful when considering accelerating systems

[23] Tangherlini's 1958 dissertation was recently made available as ([2009]).

(Selleri [2008]). Using Tangherlini's mechanics, objects with mass cannot be accelerated beyond the speed of light, in agreement with STR (Tangherlini [2009]). The essential difference between Tangherlini's ALT transformations and STR lays in the use of CS rather than SS relations. Furthermore, in light of (13), energy and momentum conservation is not violated by the use of alternative coordinate systems. As with the one-way velocity of light, the relativity of simultaneity is not part of the epistemic content of experimental observational physics.

Second, the Neo-Lorentzian is criticized for using standard simultaneity rather than absolute simultaneity relations between events (Balashov and Janssen [2003]). In light of the discussion in Section 3, is seems that these criticisms are generally unwarranted. Since the absolute present is out of epistemic reach, the presentist is free to regard the one-way speed of light as isotropic by convention. Clearly, the corresponding SS relations are the simplest. However, the presentist may wish to use CS rather than SS relations. In this case, Maxwell's equations would simply adopt their macroscopic form within a non-linear electrically polarized medium, thereby allowing for anisotropic light propagation by convention. This hardly constitutes a violation of the principle of relativity; namely, charge conservation is not violated. Therefore, SS is not required to uphold the principle of relativity.

Nonetheless, Balashov and Janssen ([2003]) suggest that the SS scheme is preferred since it may be obtained using either light signals or bullets to synchronized distant clocks. In doing so, they assume that if a specific amount of kinetic energy is imparted to a projectile of fixed rest mass, then the one-way velocity will be independent of the direction of projectile motion.[24] Thought experiments of this sort are criticized by Ungar ([1988]) for presupposing the absence of the very anisotropic effects that they intend to rule out. The concept of an observed one-way velocity is meaningless without first adopting a synchronization convention (Sonego and Pin [2009]). The use of CS relations does not constitute a violation of the principle of relativity but rather provides an alternate framework within which to make experimental observations.

To summarize, the presentist need not assume the combined postulates of the LTA and the LTB, Newtonian mechanics, or SS relations. The LTA, LTB, and the model in Section 3 each provide a simple set of postulates and serve as constructive theories to be assessed individually. The presentist isn't committed to Newtonian mechanics in order to retain absolute simultaneity. Rather, the presentist simply requires that the relativity of simultaneity does not constitute an experimentally proven fact. Indeed, Tangherlini's ([2009]) absolute Lorentz transformations conserve simultaneity relations upon transformation yet provide the same experimental results using an alternative synchrony scheme. Nonetheless, the presentist is free to use SS relations since they are usually the simplest option available for converting perceptions into observations. However, CS coordinates may be simpler to use in some cases, such as accelerating systems (Selleri [2008]). Any dynamical experiment will not yield isotropic results if non-standard CS coordinates are used. This is an artefact of the coordinate system just as SS coordinates are characterized by spatial isotropy (Sonego and Pin [2009]).

5 The Man on the Street and Presentism

[24] Regarding the dynamics of particles without assuming isotropic light propagation, see (Selleri [1996]; Sonego and Pin [2009]).

We now return to Putnam's ([1967]) man on the street, having carefully considered the implications that presentism ought to have for physics. There is one additional objection that might yet hold weight with the man on the street. The eternalist tends to assign the burden of proof to the presentist by erecting a partition between experimental evidence and human experience. For example, Callender writes ([2000]):

> 'Here I can only ask, if science cannot find the 'becoming frame', what extra-scientific reason is there for positing it? If the answer is our experience of becoming, we are essentially stating that our brains somehow have access to a global feature of the world that no experiment can detect. This is rather spooky.'

Savitt ([2000]) similarly suggests that 'If the present is indeed so elusive, I find it difficult to imagine what aid or comfort it could be to a metaphysician.' In practice, this partition is both ill defined and unnecessary. Does the well-tested hypothesis that all observers experience one moment at a time belong to mere human experience or constitute experimental evidence? Clearly physics, including STR, is unsuited to test this hypothesis yet the hypothesis remains testable. Since STR does not rule between presentism and eternalism, it is unnecessary to consider human experience as misleading. The partition between STR and human experience only serves to prevent one from taking human experience seriously.

One potential response to Callender ([2000]) and Savitt ([2000]) may be sketched as follows. In terms of human experience, the fundamental difference between temporal becoming and absolute motion is that on presentism, temporal becoming involves locally experiencing the creation (and subsequent destruction) of moments in time. Absolute motion on the other hand involves translation from one absolute location to another, both of which are likely identical by nature. Only able to experience the here and now, why shouldn't the mind detect an ontological gradient in the time direction yet not notice translation between equally existing spatial locations? Arguably, the absolute present is locally detectable and remains a stubborn reality for the reflective and unreflective individual alike. Without access to the distant absolute present, one is clearly unable to identify distant absolute simultaneity whereas the local present is unmistakable.

It seems that for the man on the street, the burden of proof lies squarely with the eternalist and that human experience demands an explanation. However, STR does not justify eternalism over presentism. Against the eternalist charge than an absolute present adds extra structure to Minkowski space-time, the presentist may rightly retort that Minkowski space-time adds extra structure to the absolute present. The eternalist belief that the absolute present ought to explicitly reveal itself is unjustified. It is clear that the absolute present is doubly hidden as a result of the prohibition against instantaneous signalling (9'). The belief that an absolute present ought to yield experimental or theoretical results different from absolute Minkowski space-time is unwarranted since conservation laws are observable independently of both synchrony and motion. Field theories correlated to conservation laws are similarly coordinate independent; rather they depend on variations and internal symmetries of the fields themselves.

To summarize, the two classic arguments against presentism based on the relativity and conventionality of simultaneity do not obtain without forcing a connection between the relative, conventional, and absolute present. The subsequent debate then hinges on who can provide a satisfactory explanation of the principle of relativity. Fortunately for the presentist, the principle of relativity is not postulated *ad hoc*; it follows naturally from the absence of instantaneous signalling. As a result, the partition erected between human experience and experimental evidence is unnecessary since STR does not rule against human experience. Therefore, one is free to choose between presentism and eternalism for some reason other than STR.

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