Presentism in a World Denied Instantaneous Signals[1]

Benjamin Nasmith – 10 Oct 2011

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, these classic arguments merely establish the mutual independence of the relevant concepts of simultaneity. The subsequent debate hinges on whether presentism or eternalism best accounts for the principle of relativity. It is demonstrated that the presentist may obtain the principle of relativity by simply prohibiting instantaneous signals between distant events. Many common objections to the presentist Neo-Lorentzian interpretation of STR are answered in light of this demonstration. Therefore, one is free to choose between presentism and eternalism for some reason other than STR.

---

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 having received 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 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.

---

[2] For a review of these first impressions, see for example (Craig [2001], pp. 129-44).

[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).

Naturally, the eternalist requires the presentist to account for the hidden character off the absolute present, an entity that simply does not exist given 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. Supposedly, the eternalist need not pay the same price.

This eternalist challenge is addressed in Section 3. By merely prohibiting distant instantaneous signalling in absolute space, the presentist may obtain a robust constructive theory. The proposed model accounts for both the principle of relativity and its wide application to all field theories 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; 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 Putnam's ([1967]) argument from the relativity of simultaneity. 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 'construct a conceptual framework in which the ideas of absolute simultaneity and the relativity of simultaneity co-exist'(Scherr et al. [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) implies that the present contains a set of simultaneous events. Premise (3) represents the relativity of simultaneity according to STR. The conclusion (4) follows from the premises. By identifying 'simultaneity' in (3) with 'simultaneous' in (2), one must choose between keeping (1) and avoiding (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

[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 the current frame of reference. Otherwise, they are drawn at an acute angle bisected by the 45-degree speed of light line.

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]; Ungar [1986]; Sonego and Pin [2009]). If the 'simultaneous' of (2) is identified with the 'simultaneity' of (5), then the conclusion (6) follows logically from premises (1), (2), and (5). The presentist must abandon (1) or concede the truth of (6).

The two arguments presented above have many variations. They 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 'simultaneity' of (5). Therefore, at best only one of the two arguments can go through. If these three concepts are indeed independent, then neither argument is cogent. 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 an ‘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.

Second, ‘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 diagonal Minkowski metric. Through an ‘external synchronization of clocks’ one observer may adopt the coordinate simultaneity of another observer in relative motion (Mansouri and Sexl [1977]). This will inevitably lead to non-orthogonal coordinates. The freedom to use either orthogonal or non-orthogonal coordinates is commonly referred to as the ‘conventionality of simultaneity’.[7]

[7] The conventionality of simultaneity has been heavily debated, with (Malament [1977]) playing a key role. See (Grünbaum [2010]) for a rebuttal. For the purpose of this paper, conventionality simply refers to the freedom to use non-orthogonal coordinates, as demonstrated in (Ungar [1986]).

Third, '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 purpose 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 premises (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 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.

---

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

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 may 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 does not 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 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 remaining physical field theories *ad*

[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 two 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]).

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 maintain 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 proposed model explains the relevant experimental evidence (Balashov 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

[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 necessarily 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.

few useful implications. As a result, the principle of relativity is implicitly postulated rather than explained. 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 existence of the absolute present (and therefore absolute space) is assumed and a prohibition against instantaneous 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 light speed isotropy or the agreement between various observers about the one-way speed of light.[13] 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

[13] Ungar ([1986]) has provided a transformation group that leaves the anisotropic speed of light constant yet reduces to the Lorentz group in the isotropic case. Therefore, observers may use different light speed conventions without sacrificing the group structure associated with the principle of relativity. Of course, transformations from the isotropic Lorentz group to Ungar's anisotropic group neither constitute a group nor violate the principle of relativity (Selleri [2005]).

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]).[14] The following definitions apply for the purpose of this discussion. A *perception* is the present local awareness of any number of simultaneously received signals. 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 itself since it is independent of both perceiver motion and distant 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]).[15] Of course, one may observe the phenomenon by using SS coordinates to calculate the nature of the optical illusion and remove it from the photographs (see Deissler [2005] for details). However, if CS coordinates are used, a different type of optical illusion will be edited out

[14] 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.

[15] 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.

of the picture.[16] 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 the 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.[17] 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').

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

---

[16] Terrell's derivation of the invisibility of the Lorentz contraction rests solely on the Lorentz transformation of 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.

[17] There is a great deal of literature on this topic as it is closely related to the conventionality of simultaneity. See for example (Winnie [1970a], [1970b]; Mansouri and Sexl [1977]; Ungar [1986]; Selleri [2005]; Tangherlini [2009]; Sonego and Pin [2009]; Iyer and Prabhu [2010]; Grünbaum [2010]).

each incoming signal at any 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. 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.[18]

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 must be synchronized in a suitable manner. Both internal and external synchronization methods are permitted. The main criterion 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 the chosen coordinate simultaneity convention, the experimenter could count the number sources detected within the laboratory. Re-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 thus far 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’),

---

[18] 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.

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 $\Sigma_0 \times R$, where R is the set of real numbers. 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 to 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, one may begin with presentism (1) and a prohibition against instantaneous signalling (9'). One may then 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 establish a correlation between conservation laws and field theories without relying exclusively on the Lorentz transformation group and its preferred SS relations. We therefore 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 fields and space-time coordinates.[19] The action is the integral of the Lagrangian with respect to the space-time coordinates over some region of their values. Physical laws are generally[20] taken to be configurations of the fields that leave the action unchanged under slight variations (adjustments) of the fields or the space-time coordinates.

Specifically, 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. 103-5,115), general continuous coordinate transformation (Barut [1980], p. 108), or small variations of the metric on a general four-dimensional manifold (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]). Alternatively, one may obtain the field equations that govern the physical fields by holding the action

[19] The Lagrangian often implicitly depends on space and time coordinates through the space and time dependencies of the fields.
[20] This requires the application of Hamilton's principle (see Mills [1989]; Brown and Holland [2004]).

constant while varying the fields themselves (Barut [1980], pp. 99-103). These variations are often referred to as internal symmetries or gauge symmetry groups (Mills [1989]). In general, the mathematical identity known as Noether's theorem correlates field theories to conservation laws (see for example Plybon [1971]; Al-Kuwari and Taha [1991]; Brown and Holland [2004]). In summary,[21]

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

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

Surprisingly, the Lorentz coordinate 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' represented by the gauge transformation groups governing each field theory.[22] Second, multiple symmetries can lead to the same conserved quantities.[23] The Lorentz transformations are simply a single case of the generalized coordinate transformation that corresponds to energy and momentum conservation.[24] Therefore, the claim of Balashov and Janssen ([2003]) that reality only corresponds to concepts that are invariant under the Lorentz group of transformations is unjustified. The Lorentz group is independent of the relevant gauge transformation groups and does not uniquely correspond to energy and momentum conservation.

---

[21] 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 laws due to variations of the action with respect to the fields and the coordinate respectively.

[22] Gauge symmetry groups U(1), SU(2), and SU(3) exist independently of the Lorentz transformations.

[23] In the case of internal symmetries, both global and local continuous symmetries lead to the same conserved values (Al-Kuwari and Taha [1991]).

[24] Indeed, Ungar ([1986]) has demonstrated that the Lorentz transformation group itself can be generalized to account for anisotropic simultaneity conventions.

Experiment is required to determine which field theory corresponds to which conservation law.[25] Since conservation laws obey the principle of relativity (12), it follows that the corresponding field theory 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 also obeys the principle of relativity.

In light of this argument, it is clear that the presentist is not obligated to detect the distant present given that it is doubly hidden by the finite signal speed restriction (9'). First, signals of finite speed do not permit the perception of distant present events. Second, conservation laws may be perceived by inferring the number of presently existing sources from the number of perceived signals. This procedure is independent of one's choice of coordinate simultaneity convention. 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 Concerning 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.

[25] Two Lagrangians will yield the same physical laws if their difference is simply a gradient with respect to the independent variables, namely the space and time coordinates (Barut [1980], p. 101; Brown and Holland [2004]).

First, the presentist relies on too many postulates to obtain the Lorentz covariance of electromagnetic phenomena. Second, the presentist fails to explain the Lorentz covariance of non-electromagnetic phenomena. One may answer both objections by connecting the Neo-Lorentzian interpretation to the model presented in Section 3. Concerning the second objection, the constructive field theory developed above may be considered a generalized version of the primarily electromagnetic Neo-Lorentzian interpretation. 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 (see for example Al-Kuwari and Taha [1991]), 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'; it posits 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 instantaneous distant signals (9'). It 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 (1) and (9') as discussed above.

Specific responses are also in order concerning the use of Newtonian mechanics and standard simultaneity relations. 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] [26] for a detailed examination of this issue). Since these two symmetry groups differ concerning the relativity of simultaneity (Baierlein [2006]), and the Lorentz group has

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

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 (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 freedom to use CS rather than solely 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 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 this criticism is 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, the absolute present is not revealed. Therefore, the use of SS relations 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.[27] 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. The use of CS relations does not constitute a violation of the principle of relativity (see Ungar [1986]; Selleri [2005]). Rather, CS relations provide an alternate framework within which to make experimental observations.

To summarize, the presentist is not restricted to merely modeling electromagnetic phenomena. Furthermore, 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 is not 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. As a result, the presentist is free to use CS or SS relations as desired. 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 (Ungar [1986]; Sonego and Pin [2009]).

---

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

5 The Man on the Street and Presentism

We now return to Putnam's ([1967]) man on the street, having carefully considered the implications that presentism ought to have for physics. It seems that for the man on the street the burden of proof lies squarely with the eternalist; human experience demands an explanation. The eternalist must therefore erect 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 so far as STR conflicts with human experience, it seems quite reasonable to prefer experimental evidence. However, since STR does not rule between presentism and eternalism, it seems unnecessary to regard human experience as misleading.

As demonstrated above, 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. Therefore, the absolute present of human experience is independent of the two major notions of the present in STR. The subsequent debate hinges on who can provide a satisfactory explanation for 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 signals. It is clear that the absolute present is doubly hidden as a result. First, distant observations are always observations of the past. Second, conservation laws are perceivable independently of both synchrony and motion. The field theories correlated to conservation laws are similarly coordinate independent; rather they depend on the variations and internal symmetries of the fields themselves. Therefore, the belief that an absolute present ought to yield experimental or theoretical results different from those of eternalist Minkowski space-time is unwarranted.

Given this model, it is unclear whether eternalism remains simpler than presentism. The epistemic principle or relativity (8') rests on humble postulates yet is applicable to any field theory correlated to a conservation law, not only electromagnetic phenomena. Against the eternalist charge that an absolute present adds extra structure to Minkowski space-time, the presentist may rightly reply that Minkowski space-time adds extra ontology to the absolute present (Crisp [2008]). It seems then that the eternalist partition between experimental evidence and human experience cannot be supported by the relativity or conventionality of simultaneity, the origin of the principle of relativity, or the apparent complexity of the presentist model.

Why then is science impotent to detect that which cannot be divorced from human experience? One potential response to Callender ([2000]) and Savitt ([2000]) may be sketched as follows. Each person experiences the absolute present locally. By assuming that others have similar experiences, at distant locations, one may infer the existence of the distant absolute present. However, since the distant absolute present is doubly hidden, one is clearly unable to pinpoint absolute simultaneity. Therefore, the brain does not strictly detect distant absolute simultaneity; STR and human experience are in agreement in this respect. As a result, the partition erected between human experience and experimental evidence is unnecessary. Therefore, one is free to choose between presentism and eternalism for some reason other than STR.

References

Al-Kuwari, H.A. and Taha, M.O. [1991]: 'Noether's theorem and local gauge invariance', *American Journal of Physics*, **59**, pp. 363-5.

Baierlein, R. [2006]: 'Two myths about special relativity', *American Journal of Physics*, **74**, pp. 193-5.

Balashov, Y. and Janssen, M. [2003]: 'Critical Notice: Presentism and Relativity', *British Journal for the Philosophy of Science*, **54**, pp. 327–46.

Barut, A.O. [1980]: *Electrodynamics and Classical Theory of Fields and Particles*, New York, NY: Dover.

Bourne, C. [2004]: 'Becoming Inflated', *British Journal for the Philosophy of Science*, **55**, pp. 107-19.

Brown, H.R. and Holland, P. [2004] 'Dynamical versus variational symmetries: understanding Noether's first theorem', *Molecular Physics*, **102**, pp. 1133-9.

Callender, C. [2000]: 'Shedding Light on Time', *Philosophy of Science (Proceedings)*, **67**, pp. S587-99.

Callender, C. [2008]: 'Finding 'real' time in quantum mechanics', in W.L. Craig and Q. Smith (*eds*), 2008, *Einstein, Relativity and Absolute Simultaneity,* New York, NY: Routledge, pp. 50-72.

Craig, W.L. [2001]: *Time and Eternity: Exploring God's Relationship to Time*, Wheaton, IL: Crossway.

Craig, W.L. [2008]: 'The metaphysics of special relativity: thee views', in W.L. Craig and Q. Smith (*eds*), 2008, *Einstein, Relativity and Absolute Simultaneity*, New York, NY: Routledge, pp. 11-49.

Crisp, T.M. [2008]: 'Presentism, eternalism and relativity', in W.L. Craig and Q. Smith (*eds*), 2008, *Einstein, Relativity and Absolute Simultaneity*, New York, NY: Routledge, pp. 262-78.

Dieckmann, J. [1988]: 'Cauchy surfaces in a globally hyperbolic space-time', *Journal of Mathematical Physics*, **29**, pp. 578-9.

Deissler, R.J. [2005]: ‘The appearance, apparent speed, and removal of optical effects for relativistically moving objects’, *American Journal of Physics,* **73***,* pp. 663-9.

Erlichson, H. [1973]: ‘The Rod Contraction-Clock Retardation Ether Theory and the Special Theory of Relativity’, *American Journal of Physics,* **41**, pp. 1068-77.

Grünbaum, A. [2010]: ‘David Malament and the Conventionality of Simultaneity: A Reply’, *Foundations of Physics,* **40**, pp. 1285-97.

Hinchliff, M. [2000]: ‘A Defense of Presentism in a Relativistic Setting’, *Philosophy of Science (Proceedings),* **67**, pp. S575-86.

Iyer, C. and Prabhu, G.M. [2010]: ‘A constructive formulation of the one-way speed of light’, *American Journal of Physics,* **78**, pp. 195-203.

Malament, D. [1977]: ‘Causal Theories of Time and the Conventionality of Simultaneity’, *Noûs,* **11**, pp. 293-300.

Mansouri, R. and Sexl, R.U. [1977]: ‘A Test Theory of Special Relativity: I. Simultaneity and Clock Synchronization’, *General Relativity and Gravitation,* **8**, pp. 497-513.

Mills, R. [1989]: ‘Gauge Fields’, *American Journal of Physics*, **57**, pp. 493-507.

Nakahara, M. [2003]: *Geometry, Topology and Physics*, Boca Raton, FL: Taylor and Francis.

Norton, J.D. [2008]: ‘Why Constructive Relativity Fails’, *British Journal for the Philosophy of Science,* **59**, pp. 821-34.

Petkov, V. [1989]: ‘Simultaneity, Conventionality and Existence’, *British Journal for the Philosophy of Science*, **40**, pp. 69-76.

Petkov, V. [2007]: ‘On the Reality of Minkowski Space’, *Foundations of Physics*, **37**, pp. 1499-502.

Plybon, B.F. [1971]: ‘New Approach to Noether Theorems’, *Journal of Mathematical Physics,* **12**, pp. 57-60.

Putnam, H. [1967]: ‘Time and Physical Geometry’, *The Journal of Philosophy*, **64**, pp. 240-7.

Savitt, S.F. [2000]: ‘There’s No Time like the Present (in Minkowski Space-time)’, *Philosophy of Science (Proceedings),* **67**, pp. S563-74.

Scherr, R.E., Shaffer, P.S. and Vokos, S. [2001]: ‘Student understanding of time in special relativity: Simultaneity and reference frames’, *American Journal of Physics*, **69**, pp. 524-35.

Scherr, R.E., Shaffer, P.S. and Vokos, S. [2002]: ‘The challenge of changing deeply held student beliefs about the relativity of simultaneity’, *American Journal of Physics*, **70**, pp. 1238-48.

Selleri, F. [1996]: ‘Noninvariant one-way velocity of light and particle collisions’, *Foundations of Physics Letters*, **9**, pp. 43-60.

Selleri, F. [2005]: ‘The inertial transformations and the relativity principle’, *Foundations of Physics Letters*, **18**, pp. 325-39.

Selleri, F. [2008]: ‘The zero acceleration discontinuity and absolute simultaneity’, in W.L. Craig and Q. Smith (*eds*), 2008, *Einstein, Relativity and Absolute Simultaneity*, New York, NY: Routledge, pp. 180-211.

Sonego, S. and Pin, M. [2009]: ‘Foundations of anisotro pic relativistic mechanics’, *Journal of Mathematical Physics*, **50**

Tangherlini, F.R. [2009]: ‘The Velocity of Light in Uniformly Moving Frames’, *Abraham Zelmanov Journal*, **2**, pp. 44-110, < zelmanov.ptep-online.com/html/zj-2009-04.html >

Terrell, J. [1959]: ‘Invisibility of the Lorentz Contraction’, *Physical Review*, **116**, pp. 1041-5.

Ungar, A. [1986]: ‘The Lorentz Transformation Group of the Special Theory of Relativity without Einstein’s Isotropy Convention’, *Philosophy of Science*, **53**, pp. 395-402.

Ungar, A. [1988]: ‘Ether and the one-way speed of light’, *American Journal of Physics*, **56**, p. 814.

Weingard, R. [1972]: ‘Relativity and the Reality of Past and Future Events’, *British Journal for the Philosophy of Science*, **23**, pp. 119-21.

Winnie, J.A. [1970a]: ‘Special Relativity without One-Way Velocity Assumptions: Part I’, *Philosophy of Science*, **37**, pp. 81-99.

Winnie, J.A. [1970b]: ‘Special Relativity without One-Way Velocity Assumptions: Part II’, *Philosophy of Science*, **37**, pp. 223-38.