**Primitive Directionality and Diachronic Grounding[[1]](#footnote-2)**

**Abstract**

Eternalists believe that there is no ontological difference between the past, present and future. Thus, a challenge arises: in virtue of what does time have a direction?Some eternalists (including Maudlin (2007), Oaklander (2012) and Tegtmeier (1996; 2009; 2014; 2016)) argue that the direction of time is primitive. A natural response to positing primitive directionality is the suspicion that said posit is too mysterious to do any explanatory work. The aim of this paper is to relieve primitive directionality of some of its mystery by offering a novel way to understand the phenomenon in terms of the recently popularised notion of *grounding*.

1. **Introduction**

We take eternalism to be the view that (a) past, present, and future objects, events, and properties exist and (b) there is no objectively present moment.[[2]](#footnote-3) Further, we suppose that there is *robust* temporal passage iff there is an objectively present moment, and which moment that is, changes. (That is, we suppose that robust temporal passage is characterised by the existence of an A-series.)[[3]](#footnote-4) Hence eternalists deny that there is robust temporal passage. Thus, a challenge arises: in virtue of what does time have a direction? One answer to this question is that time does not have a direction. Those we will call C-theorists (e.g. Price (1996)) hold just this. They hold that there exist temporal relations—C-relations—which are asymmetric and transitive, but which are *undirected*. In this regard, C-relations are a little like the relations of greater-than and less-than, or taller-than and shorter-than, all of which are both asymmetric and transitive. We can order individuals via the latter relations but in no sense (we assume) is it the case that the ordering of individuals by height has a direction: that individuals really go *from* short *to* tall, or *from* tall *to* short (likewise, we think, for integers ordered by the greater-than and less-than relations). In what follows we set the C-theory aside, not because we think it false, but because we are interested in what those eternalists who think time *does* have a direction ought say about this matter.

In what follows we will suppose that time has a direction *only if* there exist B-relations—that is, relations of earlier-than or later-than. That is, we will suppose that the B-relations, unlike the C-relations, are *directed* relations. Since eternalists think that there is no robust temporal passage, eternalists who think time has a direction think that the presence of B-relations is both necessary *and* sufficient for time having a direction. We will call such folk B-theorists. In virtue of what, however, are there directed B-relations as well as undirected C-relations?

As we argue in §2, B-theorists have two options: *primitivists* hold that B-relations do not reduce to any other relations (defenders of this view include Maudlin (2007), Oaklander (2012) and Tegtmeier (1996; 2009; 2014; 2016)).[[4]](#footnote-5) So it is simply a primitive matter that time has the direction it does, insofar as there is nothing more to be said about in virtue of what time has that direction. By contrast, *reductionists* reduce B-relations. McTaggart (1908), for instance, thinks that B-relations reduce to C-relations plus dynamical A-properties (though of course he is no B-theorist) while other reductive strategies include reducing B-relations to causal relations, or to relations of increasing entropy plus law-like boundary conditions. We call the former view *primitivist B-theory* and the latter view *reductionist B-theory*.

Primitivist B-theorists and C-theorists alike have criticised reductionist B-theories on the grounds that the various reductive bases posited by the reductionist do not do the job required: they don’t secure the existence of a directed series, and hence they cannot be the reductive base for B-relations (at best they can be the reductive base of C-relations, on assumption that these relations are reducible). C-theorists conclude that we should reject the existence of B-relations; primitivists conclude that B-relations are not reducible.

Yet a natural response to primitivist B-theory is the suspicion that primitive directionality is too mysterious to do any explanatory work. For example, Loewer (2012) complains that Maudlin’s primitivist B-theory is obscure and unexplanatory. The aim of this paper is to relieve primitivist B-theory of some of its mystery by offering a novel way to understand primitive directionality in terms of the recently popularised notion of *grounding*. Hence, in §3, we introduce grounding, and explain why identifying primitive B0relations with relations of *diachronic* ground is explanatorily fruitful. In §4, we seek to answer a further question: under what conditions do we find diachronic grounding relations in the actual world? That is: given what we know about the physical structure of our world, where (if at all) ought we think that diachronic grounding relations are actually instantiated within that structure? Finally, in §5 we respond to some objections.

1. **Directionality**

What is immediately striking about both C-relations and B-relations is that they share the same formal features: asymmetry and transitivity.[[5]](#footnote-6) So if C-relations are not directed, in virtue of what, if anything, are B-relations directed? McTaggart may have been the first to raise this worry in his seminal 1908 paper where he notes that if we just look to the formal features of the earlier-than and later-than relations, it looks as though they can ‘run’ in either direction: from earlier, to later, or from later, to earlier. That is why McTaggart ultimately thinks that the B-relations reduce to the C-relations plus dynamical A-properties: it is the movement of the A-properties along the C-series ordering of events that generates the ordered B-series.

How, then, does the B-theorist account for the existence of the B-series? Two options present themselves. The first option is to follow McTaggart in reducing B-relations, but to reduce them to something in the B-theorist’s ontology.

Reductionism is, in fact, the preferred view amongst philosophers of time, and it is not our aim, here, to argue against such a view. To see why not everyone endorses reductionism, the problem that both primitivists and C-theorists see with such views is that it is hard to see how, even if one could find some appropriate asymmetry in nature, this would do the job required.

To see why, suppose, that entropy always increases in one direction along the temporal axis from a boundary condition of very low entropy.[[6]](#footnote-7) Then we might reduce the B-relations to the relations of higher-entropy and lower-entropy (see for instance Albert (2000)). The problem is that it is hard to see why the relation of earlier-than, reduces to the lower-entropy relation rather than to the higher-entropy relation. In other words, we need to find some directed relation, or phenomenon, to which to reduce the B-relations, since the latter are directed. But while the candidates for reduction are temporally anisotropic, (such as the distribution of entropy along the temporal dimension) they are not obviously directed. It is not at all clear that we should think that things *go from* low entropy, to high entropy, rather than the converse.[[7]](#footnote-8)

One might, here, think that there are better reductive candidates. For instance, if one supposes that causation is itself directed (from cause, to effect) then the prospects arise of reducing B-relations to causal relations (see for example Mellor (1998) and Le Poidevin (1991)). Again, we won’t argue against this strategy, except to point out that this strategy is more difficult to achieve than one might have thought, since frequently we use temporal order (i.e. B-relations) to individuate which of two events is cause, and which effect. Some independent account would need to be given if we were to reduce B-relations to causal relations, as would an account of in virtue of what (if anything) causal relations are directed. Further, an account of the direction of time would, ideally, be consistent with the possibility of backwards causation. Considerations such as these have prompted some B-theorists to abandon the prospects of reduction and embrace a primitivist B-theory.

We will understand primitivism as the conjunction of two theses: a thesis about reduction and a thesis about analysis. Thesis 1 says that B-relations are irreducible. Here, we take reduction to exclude identification.[[8]](#footnote-9) So thesis 1 does not rule out that B-relations can be identified with some relation. Thesis 2 says that claims of the form ‘x is earlier-than y’ (and y is later-than x) cannot be non-trivially analysed in any other terms. In turn, A is non-trivially analysed in terms of B, in case B uses terms that refer to something other than A. So for instance, to say that ‘x is Superman iff x is Clark Kent’ is *not* non-trivial analysis of Superman, since ‘Clark Kent’ just refers to Superman.

So, for instance, our view will classify as primitivist, a view that identifies causal relations with B-relations, and, further, says that causal relations are irreducible, and cannot be analysed in any further terms. For then the only analysis of ‘x is earlier-than y’ that is available is ‘x causes y’, and that analysis is not non-trivial.

There are two varieties of primitivism. In answer to the question: ‘why is time directed from earlier, to later?’, primitivists have offered two rather different answers. Those we call *sparse primitivists* are sparsists about relations. By analogy with sparsists about properties, who think that not every predicate is associated with a real property, sparsists about relations think that not every linguistic construction of the form xRy, is associated with some real relation, R, obtaining between x and y. In particular, sparse primitivists hold that there exists the earlier-than relation, but not the later-than relation (Tegtmeier, 2009). To be clear, this is not the view that claims of the form ‘y is later-than x’ are false. Rather, it is the view that what makes those claims true is the fact that x bears the earlier-than relation to y, rather than that y bears the later-than relation to x.

Thus on this view the earlier-than relation cannot be reduced to any other nor can claims about what is earlier-than what be analysed in any other terms. But there is an explanation for the directedness of the B-series, since the earlier-than relation is itself directed (as would be the later-than, were it to exist). Tegtmeier (2009) following Russell (1937, p 95) holds that any two-place asymmetric relation holding between A and B holds in a direction—from A to B, or from B, to A. Since the later-than relation does not exist, there is no B-relation that runs in the opposite direction along the temporal axis, so it is clear what direction time has. The puzzle for this view lies in saying why it is the earlier-than relation that exists, and not the later-than relation. It seems that there is no satisfying answer to the question: why isn’t time directed (or why couldn’t it be) in the opposite direction to the way it is in fact directed?

The second version of primitivism is perhaps more familiar, and hence we call it *standard primitivism*. On this view, both earlier-than and later-than relations exist, but it is a primitive matter that time is directed from earlier to later. Maudlin’s (2007) view is an instance of such a view. We could, very roughly, think of views of this kind as identifying B-relations with C-relations plus a primitive directionality fact. The puzzle for standard primitivism is that since the directionality fact is primitive, there appears to be no answer to the question: why is the temporal arrow pointing in that direction, rather than the opposite direction?

Herein lies the mystery, and the reason that many are hesitant to sign up for the primitivist B-theory. The primitivist provides no answer to the question: why does time’s arrow point this way, rather than that way? In particular, the sparse primitivist has no answer to the question ‘why does only *this* B-relation exist, and the inverse relation does not?’, and the standard primitivist has no answer to the question ‘given that both earlier-than and later-than relations exist, why is the temporal arrow aligned with *this* relation, and not the inverse relation?’. In what follows, we attempt to demystify primitivist B-theory by identifying the earlier-than relation with a diachronic instance of a primitive relation which metaphysicians have found less mysterious: grounding. We then appeal to this notion to shed some light on these questions.

1. **Diachronic Grounding**

Following Schaffer (2009), Audi (2012), and Raven (2012), we understand grounding to be a primitive dependence relation. Grounding is, putatively, the relation by which the fundamental elements of our ontology *generate* the derivative existents.[[9]](#footnote-10) It is typically (though not universally; see Rodriguez-Pereyra (2015)) thought to be irreflexive, asymmetric and transitive, and thus to confer a partial ordering over the entities which it relates. For ease of exposition, we will follow Schaffer (2009) and Cameron (2008) in supposing that the relata of grounding can be entities of various ontological categories.[[10]](#footnote-11) Moreover, we endorse the commonly held thesis of *necessitarianism* about grounding (namely that if x grounds y, then at every possible world where x exists, y exists[[11]](#footnote-12)) and we hold that grounding is constrained by relevance, and is thus a non-monotonic relation. We remain neutral on the further questions of whether grounding is well-founded and hyperintensional.[[12]](#footnote-13)

To defend the posit of grounding,[[13]](#footnote-14) proponents have pointed to its usefulness as a philosophical tool with which to mark out and develop metaphysical views. Grounding has, indeed, proved fertile in this respect, and has been applied in areas as varied as aesthetics (Benovsky, 2012), ethics (Maguire, 2015), free will (Tognazzini, 2015) and the philosophy of time (Cusbert and Miller, 2017; Baron, 2014). The cases of free will and time are of particular interest to us here, as they extend the notion of grounding beyond the typical *synchronic* cases (those where each relatum exists at the same time) to countenance *diachronic* cases (those where the relata exist at different times). As we will understand it, (at least initially), diachronic grounding shares all the formal features of synchronic grounding. It is simply an extension of the same well-understood notion across the temporal dimension.

Like these theorists, we think that the prospects of diachronic grounding are worth exploring. In what follows, we show that diachronic grounding can also be used to develop an understanding of primitivist B-theory. In particular, in what follows we suggest that the primitivist can identify the earlier-than relation with a certain class of partial diachronic grounding relations.

Identifying earlier-than relations with grounding relations helps demystify the directedness of the B-series because grounding relations are naturally understood as *directed*, insofar as they run *from* the grounds, *to* the grounded. It is this which grounds (as it were) its being the case that the grounded are less fundamental than the grounds.

To be sure, if x grounds y, then it is also the case that y is grounded by x. In virtue of what, then, does grounding run from x to y, and not from y to x? One natural suggestion is that it is central to the very notion of grounding that grounding is a dependence relation: that the grounded depends on the grounds. Moreover, as grounding is a generative relation, it is natural to say that that grounding runs from x, to y, because x *generates* y.

We can use this insight to understand both varieties of primitivism. Consider sparse primitivism. Why is it that the relation of earlier-than exists, but the relation of later-than does not? Consider grounding relations. It seems plausible for the grounding theorist to be a sparsist about grounding relations in the following sense: grounding relations exist, but so-called ‘inverse grounding’ relations (which run from the grounded, to the grounds) do not. In other words, even though both ‘x grounds y’ and ‘y is grounded in x’ are true, they are both made true by a single grounding relation running from x to y. There is no inverse grounding relation that runs from y to x, and which makes ‘y is grounded in x’ true. That’s because there is simply no reason to suppose that inverse grounding relations exist. If earlier-than relations are identical with diachronic grounding relations then, by parity of reasoning, since there is no reason to suppose that inverse diachronic grounding relations exist, there is no reason to suppose that later-than relations exist.

Thus, if earlier-than relations are diachronic grounding relations, we can explain why only the earlier-than relation exists: namely, only that relation exists which runs from the ground, to the grounded. We can also explain in what sense that relation is directed: it is directed insofar as it is a dependence relation; for such relations by their nature run from the ‘dependee’, to the dependent.

What of standard primitivism? One possibility is to suppose that although both the earlier-than and later-than relations exist (for one is not a sparsist about relations) only one of them—the earlier-than relation—is to be identified with a relation of diachronic ground. The reason time is directed from earlier, to later, and not the converse is that earlier-than relations are identical with diachronic grounding relations, and those relations are appropriately directed. One might then say that the later-than relation exists, but is derivative on the earlier-than relation: for y bears the later-than relation to x in virtue of its being the case that x bears the earlier-than relation to y. Thus insofar as the later-than relation has a direction, it is only because the earlier-than relation does.

Hence both versions of primitivism have an answer to the question of why time is directed in the manner it is: namely because of the obtaining of relations of diachronic ground which, by their very nature, are dependence or generative relations.

There remains, however, an outstanding question. What, if anything, can we say about the connection between diachronic grounding and the physical structure of the actual world? Diachronic grounding is a primitive relation. Yet physics tells us a lot about the physical structure of our world. Though we cannot reduce facts about what diachronically grounds what to facts about the physical structure of our world, the primitivist B-theorist should expect (and hope) that there is some connection between the two. That is, she ought hope that there is some story to be told about the conditions under which diachronic grounding relations actually obtain, a story that connects up to what we know of the physics of our world. It is this question we address in what follows.

1. **Primitive Directionality and Diachronic Grounding**

On the primitivist proposal we are considering, we identify earlier-than relations with a particular class of partial diachronic grounding relations. In this section, we make clear which partial diachronic grounding relations are identical with earlier-than relations, and outline the conditions under which we find earlier-than relations in the actual world. To that end, in what follows we spell out a hypothesis regarding the connection between the actual obtaining of relations of diachronic ground, with the obtaining of other actual physical structures or processes. We return, subsequently, to the question of the modal strength of the connection we thus hypothesise.

It would be natural to say that the earlier-than relation obtains between *times*, such that one time, t, is earlier than another time, t\*, iff t diachronically grounds t\*. We would then say that an event, E, at t, is earlier than an event E\* at t\*, iff t is earlier than t\*. But in a relativistic world such as ours there is no unique way to partition the world into times. For on every way of foliating space-time into times, there will be some events, E and E\*, such that on one such foliation E will be earlier-than E\*, and on another foliation E\* will be earlier-than E. This is the relativity of simultaneity. Since none of these foliations is the preferred one (the unique right one) it follows that on different ways of foliating space-time, different sets of events will bear the earlier-than relation to one another.

The problem arises because in talking about times one thereby picks out pluralities of events such that are least some events in the plurality are *guaranteed* to be observed to occur in different temporal orderings relative to different frames of reference. Instead, we want to focus on pluralities of events which are such that for the events in that plurality, there is no frame of reference relative to which they are observed to be occur in different temporal orderings. Given what we know of the actual world, the most natural pluralities of events to consider, relative to a point, P, are those that sit on, or within, the light cones centred on P. For we know that all observers, regardless of their frame of reference, will agree in their observations regarding the order of events within and on the surface of those light cones.

In particular, for any point,[[14]](#footnote-15) P, there are two light cones centred on P, such that everything on the surface of each light cone can reach P by travelling at the speed of light, and everything within each cone can reach P by travelling at sub-luminal speeds. Call each pair of cones centred on a point, C1 and C2.

In contemporary physics one of these is known as the backward light cone and one the forward light cone. One might be tempted to conclude, from this, that in physics the direction of time is already presupposed: namely that is assumed (either as primitive or not) that what is in the backward light cone is past relative to P, and what is in the forward light cone is future relative to P. Perhaps so. But we make no such assumptions based on the existence of said light cones. After all, *nothing* about the light cone structure delivers this result. If light can move from point A to point B, then it can move from point B to point A; the relation of being-reachable-by-light is symmetric.

The light cone structure is just that: a structure. It does not, in itself, tell us anything about the direction of time. But we might well expect there to be some connection, in the actual world, between that structure and the obtaining of relations of diachronic ground. Indeed, for the primitivist who identifies the earlier-than relation with diachronic grounding relations, the most natural thing to think is that the light cone structure of our world is at least partly the result of there being certain relations of diachronic ground (perhaps there being such relations is part of the supervenience or reductive base of there being the light cone structure).

Hence it would be natural to hypothesise that actually, for any point P, and the light cones centred on P, either the plurality of events exactly located[[15]](#footnote-16) at the region at which one cone (C1) is located, diachronically grounds the event exactly located at P, or the plurality of events exactly located at the region at which the other cone (C2) is located, diachronically grounds the event exactly located at P.[[16]](#footnote-17)

Before we further develop this proposal, some clarifications are in order. First, we ought distinguish whole from partial ground. Whole ground is usually taken to be primitive, but, in essence, a whole ground of y is a ground of y that is sufficient for grounding y: it’s all you need in order for y to exist. By comparison, a partial diachronic ground of y is a ground of y, but not a whole ground. *Mutatis mutandis* for whole and partial diachronic ground.[[17]](#footnote-18)

What, then, should we say about the connection between the plurality of events in (each) of the light cones, and the relation of *whole* diachronic ground? Recall that we are supposing that diachronic grounding (that is, whole diachronic grounding) is a necessitation relation, just as synchronic grounding (that is, whole synchronic grounding) is a necessitation relation. So, if we want to locate whole diachronic grounds in our world, we should be looking for structure in our world in which we find necessitation. So, looking for whole diachronic grounding relations we should be focussing on the plurality of events within and on each light cone, not on any single one of the events in that plurality. Then if one of the pluralities of events in and on a light cone (or both light cones)[[18]](#footnote-19) necessitates the event, E, exactly located at the point on which the cone is centred, it would be natural to say that that plurality (or one of those pluralities) is the whole diachronic ground of E. Suppose, for now, that at least one of these pluralities of events necessitates E.

Given that the plurality of events within and on one of the light cones is the whole diachronic ground for E, it is natural to say that each event in that plurality is a partial diachronic ground for E. In other words an event E\* is a partial diachronic ground of an event, E, exactly located at P, iff the plurality of events exactly located at C1 diachronically wholly grounds E, and E\* is exactly located at some sub-region of C1. Then if it is the plurality of events exactly located at the region at which C1 is located which diachronically wholly grounds E, then E will *partially* diachronically ground each of the events in the plurality of events that is exactly located at the region at which C2 is located, and none of the events exactly located at the region where C2 is located will even partially diachronically ground the event exactly located at P.

Our proposal is to identify the earlier-than relation with the relation of partial diachronic ground. It follows that each of the events that in the plurality that are jointly exactly located at the region at which C1 is located, is earlier than the event, E, that is exactly located at P. This is exactly as we might hope.

This, however, cannot be quite right. Earlier, we asked the reader to suppose that at least one of these pluralities of events within and on light cone C1 or C2 necessitates E, exactly located at the point on which those cones are centred. In fact, however, this is false. So on the assumption that we want diachronic grounding to be appropriately similar to synchronic grounding[[19]](#footnote-20) (except diachronic), we cannot yet have identified the whole diachronic grounds of E.

A second pass suggestion, is to suppose that the whole diachronic grounds of E include both the plurality of events that are exactly located at C1 or C2 *and* the laws of nature. This cannot be quite right either, however, since the plurality of events that are exactly located at C1 or C2 andthe laws of nature will only necessitate the occurrence of E on the assumption that the laws are deterministic. Indeed, in an indeterministic world, it looks as though there are no diachronic necessitation relations. But then it follows that there are no diachronic grounding relations, and hence it follows that there are no B-relations either. But surely a world’s being indeterministic ought not entail that that world does not contain B-relations. So we are dissatisfied with this way of spelling out the connection between relations of diachronic ground, and the structure of our world (and other nomically possible worlds).

In fact, though, there are diachronic necessitation relations in indeterministic worlds. In such worlds there are objective chances. Those objective chances are necessitated by some plurality of events, and the laws. Consider E at P. Since we are assuming that eternalism is true, E either exists at P or not. Suppose E exists at P. Then, since E could only occur at P if there was some objective chance of it occurring, it follows that E’s occurring at P has some objective chance. The laws of nature, plus the plurality of events within one (or both) light cones centred on P, necessitate that chance. If the laws are deterministic then they necessitate that the chance is 1, and hence they necessitate E itself. If the laws are indeterministic, then they necessitate the chance of E. Hence we can make the following perfectly general claim: Actually, for any point P, and light cones C1 and C2 centred on P, either the plurality of events exactly located at the region at which C1 is located, plus the laws, L, wholly diachronically grounds the chance of E occurring at P, or the plurality of events exactly located at the region at which C2 is located, plus the laws, L, wholly diachronically grounds the chance of E occurring at P.

Since we are interested in the chances of events like E occurring at P, when E does in fact occur at P, in what follows we will suppose that we can talk as though the chance of E occurring at P itself has a location: to wit, P. Of course, there is an event, Ec, which had some chance of occurring at P, but did not. We do not want to say that the chance of Ec occurring is in any sense located at P, given that Ec does not occur at P. But we do want to talk of the location of the chance of some obtaining event, E, occurring at P. It will shortly be clear why we wish to do so. First, let’s spell out the Actual Connection between the presence of relations of whole diachronic ground, and physical structures in our world.

**Actual Connection**: for any point P, one of the light cones, C1, centred on P is such that the plurality of events exactly located at the region at which C1 is located, plus the laws, L, wholly diachronically grounds the chance of event, E, exactly located at P, occurring. [[20]](#footnote-21)

Then whole diachronic grounds obtain between pluralities of events and laws, on the one hand, and chances of an obtaining event, E, occurring at P. Then we can say the following. For two obtaining events E and E\*, E\* is earlier-than the chance of E iff E\* is a partial diachronic ground of the chance of E. It now becomes clear why we want to be able to talk of the chance of E having a location, and that location being P. For if the chance is not located anywhere, then it is nonsensical to say that E\* is earlier than the chance of E.

In fact, then, the relation of earlier-than does not obtain between events, but rather, obtains between an event and a chance of an event, where that latter event obtains. Nevertheless, that is what makes it assertible, in ordinary English, that E\* is earlier than E. For both E and E\* obtain, and E\* is a partial diachronic ground of the chance of E. Indeed, in deterministic worlds E\* is a partial diachronic ground of E, and hence it is straightforwardly the case that E\* is a partial diachronic ground of E, and thus that E\* is earlier-than E. Sine observation does not easily reveal whether a world is deterministic or not, it can hardly be any surprise that, even if our world is indeterministic, it should seem to us as though partial diachronic grounds obtain between events, rather than between events and chances of events.

One upshot of Actual Connection is that both whole and partial diachronic grounding are transitive, but trivially so. For a relation, R, is transitive iff, if R holds between a first and second element, and holds between that second element and a third element, then it holds between the first and third element. In the case in question, however, there cannot be any third element. That’s because diachronic grounding relations hold between events, on the more fundamental side, and chances of events, on the less fundamental side. Consider three events E\*\*, E\* and E. E\*\* partially diachronically grounds the chance of E\* occurring, and E\* partially diachronically grounds the chance of E occurring. But note that it is E\* itself—not the chance of E\*—that is a partial diachronic ground for E. Thus there cannot be ‘chains’ of diachronic grounding, for that which is grounded is of a different kind to that which grounds.

Of course, the following still appears to be the case: if E\*\* is a partial diachronic ground of the chances of E\*, and E\* is a partial diachronic ground of the chances of E, then E\*\* is a partial diachronic ground of the chances of E. While that’s not transitivity proper, we might call it pseudo-transitivity. The presence of this pseudo-transitivity means that something very much like transitivity will hold at the level of assertions. Consider an ordinary utterance of ‘E\* is earlier-than E’ (where E and E\* are events). If that utterance is assertible, it is because E\* is a partial diachronic ground of the chance of E. Suppose it is also assertible that ‘E\*\* is earlier-than E\*’. Then it follows that the following utterance is assertible: ‘E\*\* is earlier-than E’.

Or so we might think. But is this so? Is there even pseudo-transitivity?

In fact, it is only in worlds with flat space-time that we are guaranteed that if E\*\* is a partial diachronic ground of the chances of E\*, and E\* is a partial diachronic ground of the chances of E, then E\*\* is a partial diachronic ground of the chances of E. That’s because in flat space-time if E\* is exactly located at a sub-region of E’s C1, and E\*\* is exactly located at a sub-region of E\*’s C1, E\*\* must be exactly located at a sub-region of E’s C1.

In other words, in worlds with curved space-time[[21]](#footnote-22) diachronic grounding is not pseudo-transitive. That is because where we have curved space-time, the various light cone structures point at different angles, depending on the curvature. Thus a point P\* might be exactly located at a sub-region of C1 of P, and P\*\* be exactly located at a sub-region of C1 of P\*, but it fail to be the case that P\*\* is exactly located at any sub-region of C1 of P. What this means is that, in effect, the localised arrows of temporal directionality do not always point in exactly the same direction.

We are inclined to say, in response, that given the possibility of curved space-time, we shouldn’t expect diachronic grounding to be pseudo-transitive. Moreover, we think there is little cost in jettisoning the idea that partial diachronic grounding is pseudo- transitive. As noted, there has already been some resistance to the transitivity of grounding (Rodriguez-Pereyra, 2015), and partial grounding in particular (Schaffer, 2012) in the synchronic case. Moreover, we can explain the appeal of thinking that diachronic grounding is pseudo-transitive by noting that under most conditions we encounter, that relation will behave as though it is pseudo-transitive. In fact, in deterministic worlds with flat space-time, diachronic grounding relations will behave as though they are transitive.

So far, then, we have offered Actual Connection as a characterisation of the connection between the obtaining of relations of whole diachronic grounding, and the obtaining of certain physical features of the actual world. A question then arises as to the modal strength of Actual Connection. For our purposes, all we really need is for Actual Connection to be true, in order for it to be instructive. Nevertheless, we think there is reason to think that if it is true, then it is nomically necessarily true.

Despite appearances, however, one might worry that this is not so. For only in worlds with flat space-time do we have a guarantee that the laws, plus the plurality of events exactly located at the region at which C1 is located, necessitate the chances of E, exactly located at P. That is because in worlds with sufficiently curved space-time we get closed time-like curves (CTCs).[[22]](#footnote-23) Now consider an event, E\*, exactly located at P, which is on a CTC. The chance of E\* (and indeed, E\* itself) will fail to be necessitated by the plurality of events exactly located in the region at which C1 is located, and the laws. That’s because, to put matters informally, E\* is at least partially caused by events that are exactly located at a sub-region of C2. Hence the plurality of events exactly located at the region at which C1 is located, (plus the laws) do not necessitate the chance of E\*.

We think that the right thing to say is that this is no reason to reject Actual Connection. What this tells us is that at such points, there is no well-defined temporal direction. It doesn’t, of course, tell us that there is no well-defined temporal direction at *any* points in a world where there is such a point. In fact, quite likely, at most points there is a well-defined temporal direction. It is just that at the point in question, we cannot say anything about what is earlier-than what, because the relevant relations of whole diachronic grounding do not obtain.

1. **Objections**

Four objections potentially arise to our account of primitive directionality in terms of diachronic grounding. The first is that it might seem implausible that earlier events, objects, and properties, are more fundamental than chances of later events, objects, and properties. For instance, one might baulk at the idea that yesterday’s thunderstorm is more fundamental than the chances of today’s quantum fluctuations.

Here, the primitivist B-theorist could stop short of holding that diachronic grounding is a relation of relative fundamentality even though she holds that it, like synchronic grounding, is a dependence relation. Then she would suppose that it can be the case that x diachronically grounds y, without it being the case that x is more fundamental than y. Then she might say that the presence of diachronic grounding relations between events does not entail a relation of relative fundamentality between those events, and hence earlier events are not to be thought of as more fundamental than later events.

However, this response weakens the plausibility of the claim that diachronic grounding is simply an extension of the same well-understood synchronic notion. Thus, we think the primitivist B-theorist should bite the bullet and maintain that earlier events are more fundamental than the chances of later events. How, then, can she soften the blow of the discovery that yesterday’s thunderstorm is more fundamental than the chances of today’s quantum fluctuations? She can distinguish synchronic from diachronic fundamentality in the following way:[[23]](#footnote-24)

*Synchronic
x* is synchronically fundamental =*df* there is nothingthat synchronically grounds *x*.
*x* is synchronically derivative =*df x* is synchronically grounded.

*Diachronic
x* is diachronically fundamental =*df* *x* is not diachronically grounded.

*x* is diachronically derivative =*df x* is diachronically grounded.

*x* is fundamental, *simpliciter* =*df x* is both synchronically and diachronically fundamental.

With these notions in hand, she can insist that the intuition that macroscopic events like thunderstorms cannot ground microscopic events like quantum fluctuations is a misplaced application of the synchronic notion to the diachronic case. While it is implausible that a thunderstorm at time t is synchronically more fundamental than the chances of a quantum fluctuation at t, this tells us nothing of the plausibility of the thunderstorm at t being diachronically more fundamental than a the chances of a quantum fluctuation at t\*.

This distinction also defuses the second objection, namely that even if we think it plausible that earlier events, properties, and objects, are more fundamental than later ones, it shouldn’t be that there are *no* fundamental events, objects, and properties, other than at the first moment in time (if there is one). By distinguishing synchronic from diachronic fundamentality, we can say that although the first events, objects, or properties to come into existence (if there are any) will be diachronically fundamental, it does not follow that they are fundamental *simpliciter*, since at least some of these might be synchronically derivative. Indeed, that seems like exactly the right thing to say. Nor does it follow that there is no sense in which later events are fundamental. Later quantum fluctuations, for instance, may well be synchronically fundamental, even though they are not diachronically fundamental, or fundamental *simpliciter*. Thus there is a perfectly good sense in which today’s quantum fluctuation is more fundamental than yesterday’s thunderstorm: namely that yesterday’s thunderstorm is synchronically derivative, and today’s quantum fluctuation is synchronically fundamental.

A third objection[[24]](#footnote-25) is that, if an entity can be exactly located both at P and exactly located at a sub-region of C1, then our proposal entails that an entity can partially diachronically ground the chances of itself existing at some other time, thus violating the supposed irreflexivity of grounding. If one is an endurantist then one will suppose that such cases frequently arise. Any persisting (i.e. enduring) point-sized object will be exactly located at P, and at some sub-region of C1. Here, we think there are two options. The first is for the primitivist B-theorist to abandon endurantism, and adopt some other view of persistence—such as perdurantism or exdurantism­—that does not deliver the result that diachronic grounding is not irreflexive. The die-hard endurantist, however, might not think that diachronic grounding *ought* to be irreflexive. She might think that a good way to understand immanent causation—the relation between a thing at one time, and the very same thing at another time—is as partial diachronic grounding, such that the earlier is a partial diachronic ground of the chances of the later, even though they are one and the same thing. While such a view does not seem attractive by our lights, we can imagine it being attractive to the endurantist.

At this point, however, one might worry that the notion of diachronic grounding has strayed too far from the traditional notion of synchronic ground. If one is an endurantist one gives up on the irreflexivity of partial diachronic grounding. We have also seen that in order to accommodate curved space-time, we need to give up on the transitivity of partial diachronic ground. But then, it seems, the view we have left looks less like the traditional notion of synchronic ground. We noted previously, however, that there is already controversy regarding whether or not synchronic grounding is transitive. The same can be said for irreflexivity. Indeed, we think there is room to develop something akin to Jenkins’ (2011) *quasi-irreflexivity* here—by saying that while object O at t is identical to O at t\*, it can still be true that O at t\* partially diachronically grounds O at t. Still, it is our view that the stronger proposal is one that strays least from the traditional understanding of grounding, and rejects endurantism.

A fourth objection is that our proposal is really just a causal theory of the direction of time.[[25]](#footnote-26) Let’s suppose this is the view that the B-relations can either be reduced to the C-relations plus causal relations, or just to causal relations, where in either case causal relations are taken to be intrinsically directed. One might think that this bears similarities to our account insofar as we appeal to the light cone structure and one might think of the light cone structure as capturing causal connections between events.

First of all, it’s worth noting that the primitivist view we outline is not a reduction of B-relations to causal relations. Actual Connection is a hypothesis about the connection between physical structures in our world, and the presence of relations of whole diachronic ground. That might mean that there are actual (or nomically necessary) connections between whole or partial diachronic grounding relations and relations of causation, if there are such connections between causation and the light cone structure. If so, then so be it: there are nomically necessary connections between diachronic grounding and causation. Nothing in our account ensures that this, however, is so. Our proposal is entirely consistent with causal relations entirely coming apart from the direction of time. It is also consistent with there being worlds with a B-series and no causal relations at all.

All the light cone structure does is model facts about whether sub-luminal signals can reach A from B, or whether only luminal signals can reach A from B, or whether only superluminal signals can reach A from B. The connection between these signalling facts and causation remains an open question. Indeed, nothing we have said here requires that causation is directed. For all we have said, it could be that causation is symmetrical (see Braddon-Mitchell (2017)) and Price (2007)) and hence has no direction, so that there is no objective matter of fact which relata is cause, and which effect. It is, indeed, consistent with what we have said that causal eliminativism is true, or that the causal arrow does not align with the primitive temporal arrow. Perhaps, as a matter of fact, you think it does, because you think that there are important connections between the light cone structure and the causal structure. But nothing in our proposal requires that this be so.

1. **Conclusion**

In this paper we have not attempted to defend diachronic grounding as a posit, nor to argue that primitivist B-theory is a good way to understand temporal direction. Rather, we have assumed that we have a reasonable grip on the notion of synchronic grounding, and have extended that notion to include diachronic grounding. Having done so, we have identified partial diachronic grounding between events and chances of events, with the B-relation of earlier-than, and in so doing, have attempted to show why it is plausible that, so understood, the relation of earlier-than is in fact *directed*. We then went on to outline Actual Connection, that links the obtaining of diachronic grounding relations to physical structure in our world (and perhaps nomically possible worlds) in an attempt to further demystify primitive direction.

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1. None of the authors have any conflict of interest associated with this manuscript. [↑](#footnote-ref-2)
2. Sometimes eternalism is taken to be the thesis that includes (a) but not (b), so that the moving spotlight theory is a version of eternalism. This is not how we are using the term. [↑](#footnote-ref-3)
3. There have been deflationary (i.e. non-robust) accounts of temporal passage which take it to be something less robust than this. For instance, Savitt (2001; 2002) defends the view that temporal passage consists in there being a sequence of temporally ordered events, and Maudlin (2007) defends the view that temporal passage consists in there being an intrinsic asymmetry in the temporal structure of the world. [↑](#footnote-ref-4)
4. According to Oaklander (2012), Russell (1915) also endorsed primitivist B-theory. This is why he calls his theory the R-theory (Russellian theory of time). Russell’s view is also the precursor of that defended by Tegtmeier (2009). [↑](#footnote-ref-5)
5. Here, we assume that the B-relations include only the relations of earlier-than and later-than: we can then define the relation of being simultaneous-with, as being the relation that obtains between events E and E\* when it is neither the case that E is earlier than E\*, nor the case that E\* is earlier than E. That relation, of course, is symmetric. In worlds without a preferred foliation of events into times (such as our world) we could instead say that relative to a frame of reference, R, E and E\* are simultaneous iff relative to R, it is neither the case that E is earlier than E\* nor the case that E\* is earlier than E, and at R, E and E\* are observed to occur at the same time. [↑](#footnote-ref-6)
6. Statistical mechanics shows that this will almost certainly be false, but let’s suppose it anyway. [↑](#footnote-ref-7)
7. See for instance Price (1996; 2007) for arguments of this kind. [↑](#footnote-ref-8)
8. If you think that identification is a limiting case of reduction, then the view is that B-relations cannot be reduced to anything with which they are not numerically identical. [↑](#footnote-ref-9)
9. Thus, the notion of grounding we have in mind is not one according to which the grounded is ‘nothing over and above’ its grounds. We follow Audi (2012) in supposing that if x grounds y, x in some sense metaphysically explains y, but x and y are distinct. [↑](#footnote-ref-10)
10. Nothing hangs on this. Those who, like Audi (2012) prefer to restrict the relata to *facts* are free to reformulate our proposal in those terms. [↑](#footnote-ref-11)
11. Notice that it does not follow from this that any x which necessitates y also grounds y; that x necessitates y is a necessary, but not sufficient, condition for x grounding y. [↑](#footnote-ref-12)
12. See Raven (2016) for an interesting proposal regarding the former and Duncan, Miller and Norton (2017) for a discussion of the latter. [↑](#footnote-ref-13)
13. For criticism, see Hofweber (2009), Daly (2012), Wilson (2014), Koslicki (2015) and Miller and Norton (2016). [↑](#footnote-ref-14)
14. Where by ‘point’ we mean space-time point. [↑](#footnote-ref-15)
15. Here we use ‘exact location’ as it is used in Gilmore (2017) to pick out a primitive locational relation that obtains between objects and space-time. A rough characterisation of this primitive notion, however, is that an exact location of an object is the region that shares that object’s size and shape, or its size and shape at a time, and which is effectively the object’s *shadow* in space-time.

Further, we suppose that some *plurality* of events is exactly located at a region R, iff each member of that plurality is exactly located at some sub-region of R. We remain neutral about whether objects can have more than one exact location: that is, whether it is possible for objects to be multiply located throughout space-time in the way that endurantists suppose them to be and perdurantists do not. [↑](#footnote-ref-16)
16. Here, by ‘exactly located at’, we intend to include space-time points exactly located on the surface of the cone as well as inside the cone. [↑](#footnote-ref-17)
17. This is nothing new: the distinction between whole and partial diachronic grounding is directly analogous to the whole/partial distinction commonly drawn in discussions of grounding. The kind of partial grounding we are using here corresponds with Dixon’s (2016:276) Proper Partial Grounding. A whole ground entirely accounts for (and necessitates) that which it wholly grounds. A partial ground is a proper part of a whole ground, and need not necessitate that which it partially grounds. [↑](#footnote-ref-18)
18. It will be both if the laws are temporally symmetric. [↑](#footnote-ref-19)
19. While, as we noted above, necessitarianism is commonly accepted (e.g., Audi, 2012), see Leuenberger (2014) and Skiles (2015) for defences of *contingentism* about grounding. [↑](#footnote-ref-20)
20. It is worth noting that accepting Actual Connection ought push one towards accepting some non-Humean account of the laws. Maudlin (2007), for instance, already accepts such an account. For if one accepts a Humean account and holds that the laws supervene on the totality of matters of fact in space-time then saying that chance of the event E exactly located at P is wholly diachronically grounded by the plurality of events exactly located at the region at which C1 is located, plus the laws, is really saying that the chance of E is jointly wholly grounded in *everything*. Then Actual Connection is implausible, since it entails that everything in the manifold jointly wholly diachronically grounds the chance of E. Since we identify the earlier-than relation with the relation of partial diachronic grounding between an event and a chance of an event, this entails that everything in the manifold is earlier-than the chance of E. We take that to be a reductio on such a view. [↑](#footnote-ref-21)
21. Even in worlds that lack CTCs. [↑](#footnote-ref-22)
22. Technically, there can be CTCs in a flat space-time, when the solutions to Einstein’s Field Equation are curved, so long as there is any non-zero stress-energy tensor. For present purposes we set aside these technicalities. [↑](#footnote-ref-23)
23. In this we follow Baron (2014). However, Baron distinguishes these notions in a somewhat different manner than we do (since he includes mention of times). His distinctions are below. We assume that location is to be read as exact location.

*Synchronic***FundamentalS** *x* is fundamentalS =*df* If *x* is located at time *t*, then there is nothing at *t* that synchronically grounds *x*.
**DerivativeS** *x* is derivativeS =*df* If *x* is located at time *t*, then there is something at *t* that synchronically grounds *x*.

*Diachronic***FundamentalD** *x* is fundamentalD =*df* If *x* is located at time *t*, then (i) *x* is fundamentalS and (ii) there is nothing at *any* time *t\** such that *t\** ≠ *t* that diachronically grounds *x*.

**DerivativeD** *x* is derivativeD =*df* If x is located at time *t*, then there is something at a time *t\** such that *t\** ≠ *t* that diachronically grounds *x*. [↑](#footnote-ref-24)
24. Raised by an anonymous referee. [↑](#footnote-ref-25)
25. As contrasted with the causal theory of time, which holds that we can reduce temporal relations to physical relations, i.e. to relations of causation. [↑](#footnote-ref-26)