**Quantum Gravity, Timelessness, and the Folk Concept of Time**

**Abstract**

What it would take to vindicate folk temporal error theory? This question is significant against a backdrop of new views in quantum gravity—so-called timeless physical theories—that claim to eliminate time by eliminating a one-dimensional substructure of ordered temporal instants. Ought we to conclude that if these views are correct, nothing satisfies the folk concept of time and hence that folk temporal error theory is true? In light of evidence we gathered, we argue that physical theories that entirely eliminate an ordered substructure vindicate folk temporal error theory.

1. **Introduction**

The question of what is both necessary and sufficient for there to be time has become pressing, of late, in the wake of so-called timeless theories of quantum gravity. Such theories have been proposed by physicists in an attempt to bridge general and special relativity with quantum mechanics (Barbour (1999) (1994b) (1994a), Butterfield and Isham (1999), Anderson (2006, 2009, 2017), Deutsch (1997), Gell-Mann and Hartle (1994), Dodd and Halliwell (2003), Rovelli (2004) (2007), (2011), Rovelli and Vidotto (2015) Dowker (2006), (2013) (2014), Rideout and Sorkin (1999).

 There are various approaches to quantum gravity that are said to be timeless.

These theories are typically taken to be timeless because the completed theory lacks a one-dimensional substructure of ordered temporal instants, as well as any temporal metric, or distance relations, between those instants. Importantly, following Braddon-Mitchell and Miller (2019) let’s distinguish *weakly* timeless theories from *strongly* timeless theories. Then weakly timeless theories are theories in which although there is no substructure of ordered instants posited at the fundamental level, such an ordering is emergent. Strongly timeless theories are ones on which not only is no such ordered substructure posited at the fundamental level, but in addition, it does not emerge at higher levels.

 Some approaches to quantum gravity are widely agreed to be strongly timeless.

One of these is Barbour’s (1999, 1994b, 1994a) Machian theory, on which there is a relative configuration space populated by three-dimensional objects, each of which is a Riemannian three-geometry. Importantly, the configuration space itself contains no spatio-temporal metric: the objects in that space bear no metric relations to one another, nor does its description in terms of the Wheeler-DeWitt equation mention any spatio-temporal relations. Moreover, there is no suggestion that such a metric in some way emerges at a higher level. By contrast, it is less clear whether other approaches are strongly, or only weakly, timeless. Two of these approaches include loop quantum gravity approaches such as those defended by Rovelli, and causal sets approaches such as those defended by Dowker, Rideout and Sorkin.

According to loop quantum gravity approaches, very roughly, fundamentally there exist spin-networks, where each spin-network can be represented by a directed graph of interconnected vertices and edges. Then each vertex represents a three-dimensional volume of space, and each edge represents a two-dimensional surface. On this picture, fundamentally reality is composed of discrete chunks of space, tied together into a structure, but where those ties can’t be mapped to a spatio-temporal metric (see Lam and Wuthrich 2018).

By contrast, the causal sets approach is one on which fundamentally there exist four-dimensional space-time atoms, and these are partially ordered by a ‘causal’ relation. (We use scare quotes here for good reason: while the formal relation that is defined in such models shares some of the formal properties of the causal relation as we conceive it in philosophy (and more generally) it is unclear that it really counts as a causal relation in this latter sense at all). A causal set, then is an ordered pair of such atoms and the causal relation, and such sets gradually come into existence.

It is controversial whether various versions of loop quantum gravity approach and the causal sets approach are strongly timeless or instead are only weakly timeless. Dowker, for instance, clearly thinks that her version of the causal set approach are only weakly timeless, since she thinks it provides an account of temporal flow (Dowker 2014). It has, however, remained generally unclear how space-time, and in particular, how a *temporal* metric, emerges from accounts of either kind. Huggett and Wuthrich (2013), for instance, note that there is nothing in causal set theory that corresponds to space-time intervals and, they argue, there is no alternative interpretation of the theory in terms of metric relations that is available. Others have voiced similar concerns about the emergence of a spatio-temporal metric from loop quantum gravity models. Lam and Wuthrich (2018) for instance, note that at best, proponents of such theories have shown that space can emerge, not that space-time does[[1]](#footnote-1). So even though most proponents of loop quantum gravity and causal sets approaches aim to show that their theories are weakly, but not strongly, timeless, it is not yet clear whether they have, or will, succeed in this endeavour.

Whether there is, or can be, a good account of how space-time emerges from something fundamentally non-spatio-temporal is is not something about which we wish to take a stand. For the purposes of this paper, we focus only on strongly timeless theories, whichever exactly those theories turn out to be. Our point, here, is just that given the difficulties of showing how space-time emerges from something fundamentally non-spatio-temporal, at this stage we ought not be so sanguine as to suppose that the only theories that fall into the category of strongly timeless are the Machian ones of Barbour.

We focus on strongly, rather than weakly, timeless theories, because we are interested in investigating the folk concept of time, and, in particular, the conditions under which that folk concept goes unsatisfied (i.e. nothing actually falls under it).

An obvious hypothesis is that in order for the folk concept to be satisfied there must exist an ordered substructure of instants, *whether fundamental or emergent*.[[2]](#footnote-2) This is the hypothesis on which we focus.

 Of late there has been significant interest in the folk concept of time (Baron and Miller 2015a 2015b; Tallant 2018; Braddon-Mitchell and Miller 2017; Latham, Miller and Norton (2019). In what follows we will call ‘folk time’ that thing, if there is anything, that falls under the folk concept of time. Then our key question regards the conditions under which the folk concept of time goes unsatisfied, and hence there is no folk time. In turn, the question arises as to when we ought conclude that *folk temporal error theory* is true. There have been a number of attempts to spell out the conditions under which temporal error theory is true (see Tallant 2018 and Baron and Miller 2015b), but little agreement has been reached. In what follows we will suppose something we take to be uncontroversial: folk temporal error theory is true just in case our temporal discourse, and the temporal thoughts there expressed, are systematically false (or at least, not true). Where disagreement lies is in what it would take for our temporal thoughts to be systematically false. Tallant suggests that they would be false just in case there are no present-tensed truths. Baron and Miller (2015a; 2015b) suggest that they would be false just in case (roughly) our folk concept of time is unsatisfied, and is so because the thing in the world responsible for the appearance of time does not underlie, ground, or explain, the phenomena, including causation, persistence, and change, that we take to be inextricably connected with time.

 We take it that most parties to this debate will agree that our temporal thoughts (and hence discourse) is systematically false if the concept of time that is employed in those thoughts is not satisfied: where they disagree (we take it) lies in what it would take for the folk concept of time to fail to be satisfied. So in what follows we will suppose that folk temporal error theory is true if[[3]](#footnote-3) our folk concept of time is not satisfied. Then we are interested in whether, if a strongly timeless theory is true, this entails folk temporal error theory by entailing that our folk concept is unsatisfied.

 Why, though, ought those interested in the philosophy of time care about the *folk* concept of time, and whether or not it is in error?

Well first, we think there is good reason to care about the content of the folk concept, and hence to care about the conditions under which it would be in error (regardless of whether or not it is). Since at least as far back as McTaggart (1908), appeals have been made to what it would take for there to be time, where one way to understand this is as an appeal to what it would take for the folk concept (or perhaps something appropriately precisified) to be satisfied. More recently, some have suggested that it is part of our folk concept of time that time passes (Williams 1998; 2003), while others have argued that dynamical accounts of time get *something* right about the way we ordinarily think about time.[[4]](#footnote-4) Dynamists, in turn, conclude that this gives us defeasible reason to embrace dynamism.[[5]](#footnote-5) Even non-dynamists often concede that they incur the burden of explaining why dynamism gets *something* right about how we ordinarily think about time, given that time is not in fact dynamical.[[6]](#footnote-6) To be clear, we are not endorsing any argument of the form: because the folk concept of time is thus and so, we have (even defeasible) reason to conclude that time is thus and so. But some people do reason that way, and it would be nice if their appeals to the putative content of this concept were not based entirely on armchair reflection. Moreover, if the folk concept of time turns out to be radically different from the way time, in fact, is, given our best physics, we ought explain how it is that we came by such a mistaken concept. But in order to know whether any such explanation is needed, we need to know something about the content of that concept.

 Second, we want to know whether, if these sorts of timeless theories are true, what they eliminate is *folk* time. We ought care about whether they eliminate folk time, because it is folk time that is conceptually connected to a range of other, important, concepts. As Baron and Miller (2015a 2015b) point out, folk time seems to be crucial to a number of important notions, including, but not limited to, causation, deliberation, agency, persistence and personal-identity. The folk notion of time seems central to the idea that there exist person-stages located at other times, on which we can causally impinge, such that it makes sense to deliberate, now, about what to do at later times. Indeed, our understanding of ourselves as temporally extended entities with a life-story that makes sense of who we are, at any moment, seems to rely on the idea that there is folk time (Baron, Miller and Tallant forthcoming). So whether there is folk time is something we all ought care about: for our folk concept of time lies at the centre of a web of related notions that are central to us being the sorts of things we take ourselves to be.

 So we want to know the conditions under which our folk concept of time goes unsatisfied. We want to know whether, if a (strongly) timeless theory is true, our folk concept of time is unsatisfied. For it could be that although these theories are genuinely timeless in some sense, what they eliminate is not folk time. Perhaps they eliminate something about which the folk care very little, because that thing is not centrally connected to the interrelated concepts of agency, causation, personal-identity and so forth, about we care a great deal. Given the central role that the *folk* concept plays in this web of concepts, we want to know whether the discovery that such a strongly timeless theory is true, would threaten to render in error, all the concepts in that web.

Now, to be clear, we do not arguing that one can marshal arguments for, or against, timeless theories by appealing to the content of the folk concept. This is not to say that such arguments *couldn't* be marshalled. Suppose, for instance, that we discover that these theories eliminate folk time. Then one could argue that since folk time is central to notions of agency and personal-identity which are, in turn, central to our very way of understanding ourselves and being in the world, that we have reason to think that such notions are not in error. But if folk time were eliminated then such concepts would be in error, and hence we have reason to think that folk time is not eliminated, and so we have reason to reject any theory on which it is. We are not inclined to find such arguments persuasive, but there are surely those who might. We do think, however, that it matters a good deal to our theorising about a whole range of issues, whether or not our folk concept of time is in error. If we came to have good reason to think that a timeless theory were true, and if that theory eliminated folk time, then either we would need to begin the project of developing new, timeless, notions of causation, deliberation, agency, and personal-identity, or begin the task of showing how to make sense of our lives on the assumption that there is no causation, deliberation, agency or personal-identity. If, on the other hand, timeless theories do not eliminate folk time, then neither of those projects is one with which we would need to engage. This paper aims to empirically investigate determine whether strongly timeless theories eliminate folk time, by investigating whether the folk concept of time is satisfied only in worlds containing a substructure of ordered instants.

We begin, in §2, by clarifying some key terms and examining the relevant literature. In §3 we outline the methodology for two experiments we ran, and in §4 we discuss the results of those experiments for debates about the conditions under which temporal error theory is true.

**2. The Literature**

We will suppose that a *folk theory of time* is a, probably tacit, theory of what time is like in our world. Philosophical theories of time—presentism, the growing block theory, the block universe model and so on—are examples of such theories. We will assume that folk theories can be more, or less, similar to these philosophical theories, and that we can go some way towards determining the content of someone’s folk theory by describing a number of ways our world might be, and asking them which way they think is most like our world.

We will call those whose folk theory of time is more similar to a theory in which there is some substructure along which instants are ordered, an *orderist*, and those whose folk theory of time is more similar to a theory in which there is no substructure along which instants are ordered, *non-orderists.*

Then there are many ways of being an orderist. At one end of the spectrum one can be some kind of A-theorist, or, as we will more commonly say, a dynamist. In that case one thinks that the ordering relations between instants is a function of temporal passage—it is grounded in the order in which events become present, i.e. the A-series.[[7]](#footnote-7) Alternatively, one can be a B-theorist. As we will understand it, the B-theory is a theory on which there is an ordered substructure of instants, and that ordering is generated by B-relations, which are directed, and asymmetric, [[8]](#footnote-8) such that time has a privileged direction. Then one is a B-theorist if either one thinks that time’s having a direction is a primitive or fundamental matter (Maudlin 2007, Oaklander 2012 and Tegtmeier 1996; 2016; Kajimoto, Miller and Norton forthcoming) or that time’s having a direction reduces to there being some other, directed, asymmetric relation like causation ((Mellor 1998; Le Poidevin 1991) or reduces to there being an asymmetric distribution of certain properties through time (such as, for instance, the increase of entropy away from a boundary condition (Loewer 2012; Albert 2000). Finally, orderists can be C-theorists. As we will understand it, the C-theory is the view there exist a sub-structure of ordered instants, where this ordering is generated by an asymmetric, but undirected C-relation[[9]](#footnote-9). (Price 1996; Farr 2012). On this view although temporal instants are ordered, there is no fact of the matter as to whether time is directed from t to t\*, to from t\* to t: no fact of the matter as to which direction is past, and which future.

Whether instants are ordered via an A-series, a B-series, or a C-series (or some combination thereof) there is some fact of the matter as to which order those instants are in. Even if not all such views *strictly* take there to be a substructure along which the instants are ordered[[10]](#footnote-10) they all agree that there is some appropriately robust ordering relation that obtains between these instants, where we could correctly represent that ordering in terms of there being a substructure along which said instants are arrayed. Henceforth, then, when we say a theory is one on which there is a substructure of ordered instants, we intend to include theories on which strictly speaking there is no such substructure, but we can *correctly represent* the true ordering of instants in terms of a substructure along which said instants are arrayed.

A non-orderist, then, is someone whose folk theory of time is most similar to a theory on which there is no substructure of ordered instants. In our experiments we focus on one way of being a non-orderist: having a folk theory that is most similar to a particular quantum gravity theory which, for ease of discussion, we call the D-theory. The D-theory is, very roughly, a theory on which there is a configuration space of instants, but in which there is no substructure of ordered instants.

Though there is a wealth of empirical research into the ways in which people represent time through metaphorical language (especially using spatial metaphors), through diagrams (representations of a time-line) and through gestures (pointing in a particular direction to point towards the future, or the past) and, in particular, research into the cross-cultural variability of the ways that people represent time (see Evans, 2003, 14; Sinha and Gardenfors (2014) (Boroditsky 2008) Boroditsky, Fuhrman, McCormick 2010) (Fuhrman, McCormick, Chen, Jiang, Shu, Mao, & Boroditsky 2011) (Chen 2007; Boroditsky 2001); Casasanto & Bottini, 2014) (Nunez et al 2012), there has been no research into whether people think that the presence of a substructure of ordered instants is *necessary* for there to be time. That is, there has been no research into whether people’s folk *concept* of time can only be satisfied if there is such a structure.

When we talk of a folk concept of time, by ‘concept’ we mean a contentful mental state that can be a constituent of a thought. We don’t assume that all concepts are explicit: we think that some, including quite likely the folk concept of time, are tacit. That is, individuals who employ those concepts will likely not be able to articulate their content, let alone provide anything like necessary and sufficient conditions for something to satisfy that concept. That is why in our experiments we don’t ask people to describe the content of their concept, instead, we ask them to *use* the concept by judging whether or not certain scenarios are ones in which there is time. In this regard, we assume that people’s behaviour—linguistic and otherwise—provides evidence regarding the content of concepts, whether tacit or explicit.

Nor do we assume that there is a single, folk concept of time that is shared either across, or within, cultures. Our sample is drawn exclusively from the US, and so all our claims are claims about the population from which this sample is drawn. Our results might not generalise to other populations. Moreover, it may be that there are *multiple* folk concepts of time even within this population, so we will typically talk about the folk *concept(s)* of time, to draw attention to the fact that there may be more than one such concept, even in this population. In this work, however, our goal is not to investigate the question of whether, or how many, different concepts of time there are in the population tested. Rather, we want to know whether most of this population has a concept (whether the same or not) such that the presence of an ordered substructure of instants is *necessary* for that concept to be satisfied. It may be that there are multiple concepts in the population; nevertheless, if those concepts are all (or almost all) only satisfied if there is an ordered substructure of instants, then we learn something important. Namely, we learn that there is some way things could actually go such that most people’s folk concept of time is unsatisfied, and hence, at least for these people, temporal error theory is vindicated. Interestingly, it remains a live possibility that for some minority of the population who deploy a different folk concept of time on which the presence of an ordered substructure is *not* necessary for time, that their folk concept is satisfied in this event, and, in turn, that for them, temporal error theory is not vindicated.

 In order to investigate the question of whether an ordered sub-structure of instants is necessary for the folk concept(s) of time to be satisfied, we need participants to make judgements about whether there is time in some scenario in which there is no such substructure. We know, however, that how people respond to such scenarios often varies depending on whether they are thinking of a scenario as describing a way our world could have been, but is not, (a scenario considered as counterfactual) or thinking of it as describing a way our world has been, or might be, discovered to in fact be (a scenario considered as actual).[[11]](#footnote-11)

To get a feel for why this might be, consider the case of free will. It might be that people have a concept of free will on which if there are actually special agent causal powers, then these turn out to be necessary for free will. Then any scenario people entertain as counterfactual, in which these powers are absent, will be judged to lack free will. Still, it might be that people are also such that if they were to discover that our world lacks these special powers, they would judge that the presence of certain mental states appropriately connected to action, (or whatever else might do the work here) was sufficient for free will, and hence just that these special causal powers are not necessary. So how people respond to a scenario in which there are no such special causal powers present might depend on whether they are thinking of that scenario as describing a counterfactual scenario, or as describing a way our world has been discovered to be.

Given this, there are two hypotheses we can entertain about the role that the presence of an ordered substructure of instants plays in the (relevant) population’s folk concept(s) of time. First, it might be that the presence of this substructure is judged to be *absolutely* *necessary* for time: it is judged to be necessary for there to be time regardless of how the actual world is supposed to be. Second, it might be that the presence of this substructure is judge to be *conditionally necessary* for time: it is judged to be necessary for there to be time, but only conditional on its turning out that actually, there is such a structure. Or, third, the presence of this substructure might be neither absolutely nor conditionally necessary.

 Importantly, then, when we ask participants questions about whether they judge there to be time in a scenario, we first want to ascertain how they in fact suppose our world to be, with regard to the presence of an ordered substructure of instants. Then we want to ask participants to suppose that our world has been discovered to be some way (to entertain a scenario as actual) and to judge whether or not there is time in that scenario, considered as actual. We then want to ask participants to make judgements about a counterfactual scenario (which we describe to them as a parallel universe) conditional on them supposing the actual world to be as we have specified. We can then determine whether people’s folk concept(s) are one on which the presence of an ordered substructure of instants is absolutely or conditionally necessary for time, or neither.

A further complication is that it might be that whether a participant’s folk concept is one on which the presence of an ordered substructure of instants is absolutely or conditionally necessary, might vary depending on how they *in fact* suppose our world to be. For instance, it could be that non-orderists do not take the presence of an ordered substructure of instants to be absolutely or conditionally necessary for there to be time, while orderists take the presence of such a structure to be, say, conditionally necessary. To see whether this is so, we need to divide participants into orderists and non-orderists and then see how they respond to the various scenarios considered as actual or counterfactual.

 Bearing all this in mind, then, what ought we predict about the role of the presence of an ordered substructure of instants in people’s folk concept(s) of time? Well we had very little evidence to use in developing hypotheses. There is one previous study that we were able to draw upon. Latham, Miller and Norton (2019) aimed to determine what folk *theory* (not concept) of time people deploy. They found that amongst their sample, also US residents, a majority (~70%) were temporal dynamists of some kind—most were growing block theorists—with a minority (~30%) being divided between some kind of non-dynamical ordered theory (B-theory or C-theory) and the D-theory. Unsurprisingly, Latham et al found only a very small proportion of participants were D-theorists.

Based on these findings, we predicted that only a small minority of participants would be non-orderists. Given this, we thought it likely that even with a large sample of participants there might be insufficiently many non-orderists to perform comparative statistical analyses. Hence the only predictions we made were (1) that that there would be a small minority of non-orderists amongst the population, and (2) that a majority of non-orderists would judge both that there is actually time (i.e. there is time in an unordered scenario considered as actual) and that a majority would judge that there is time in an unordered scenario considered as counterfactual.

We focussed most of our predictions on the population of orderists, which we assumed would be most of the population. There, based only on armchair consideration of our intuitions, we predicted (3) that mean levels of agreement that there is time in an ordered scenario would be significantly higher than mean levels of agreement that there is time in an unordered scenario and (4) that mean levels of agreement that there is time in an ordered scenario will be statistically significantly above 4 (neither agree nor disagree) and mean levels of agreement that there is time in an unordered scenario would be statistically significantly below 4. We also predicted (5) that a majority of orderists would judge that there is no time in an unordered scenario, *regardless of whether they were evaluating it as actual or as counterfactual.* Moreover, we predicted that (6) there would be no statistically significant differences between orderists’ judgements regarding whether there is time in an unordered scenario considered as actual or considered as counterfactual. So we predicted that orderists would take ordering relations to be absolutely necessary for time.

**3. Experimental Design and Results**

We ran two experiments to test these hypotheses. Since we felt that there might be a difference in responses between orderists who think that a dynamical scenario is most like our world, and orderists who think that a non-dynamical scenario is most like our world, we ran two experiments. In both of these the non-orderist scenario is represented by a vignette describing the D-theory scenario. But in experiment 2 the orderist scenario is represented by a vignette describing a dynamical (a growing block) scenario, and in experiment 1 it is represented by a vignette describing a non-dynamical (C-theoretic) scenario.

In both experiments participants are first presented with all three vignettes and asked which they think describes a universe (we use the term universe rather than scenario or world) that is most like ours. This allows us to group participants not just into those who are orderists and those not, but also to group orderists into *dynamical orderists*—those who think a dynamical world (the growing block world) is most like our world—and *non-dynamical orderists*—those who think a non-dynamical world (the C-theory world) is most like our world. Our predictions about the judgements of orderists are predictions about the judgements both of dynamical orderists and non-dynamical orderists.

Participants in each experiment then see a pair of vignettes, one of which is an ordered scenario and the other an unordered scenario. In experiment 1, participants see (in random order) the C-theory ordered scenario and the D-theory unordered scenario, while in experiment 2 participants see (in random order) the growing block ordered scenario and the D-theory unordered scenario.

After having seen the first vignette participants are told that scientists have discovered that our universe is just like the universe described in the vignette. They are then asked whether the vignette describes a universe that contains time. The process is then repeated for the second vignette. Finally, in both experiments participants see both vignettes side by side. But in one condition participants are told that vignette 1 is our universe, and vignette 2 is a parallel universe and in the other condition participants are told that vignette 2 is our universe and vignette 1 is a parallel universe. In both conditions participants are then asked whether there is time in the parallel universe.

 Given our aims, it was important that the descriptions of the scenarios in the vignettes did not explicitly mention time, times, or temporal relations, or otherwise use temporal locutions. For instance, if a scenario is described in terms of there being events that are earlier-than, and later-than, other events, this strongly suggests that there is time in that scenario. Hence we wrote the vignettes in ‘time-neutral’ form: describing the scenarios without using temporal locutions. Since this makes it difficult to understand the vignettes, we introduced the locution: ‘some scientists, philosophers and theologians in universe C/D/E think that…’ and then the ellipses included a description of the scenario using temporal language. Our aim was to provide both a time-neutral and non-neutral description of the scenarios, so that participants could then bring to bear their concept of time to determine whether they think there is time in the scenario described. Due to this we had concerns that participants might not understand the vignettes. Hence we included three comprehension questions at the end of the vignettes. The results we report only include those from participants who got at least 2 out of 3 of the comprehension questions correct for each of the vignettes they saw.

**Experiment 1**

**3.1 Method**

*3.1.1 Participants*

420 people participated in the study. Participants were U.S. residents, recruited and tested online using Amazon Mechanical Turk, and compensated $2 for approximately 20 minutes of their time. 66 participants had to be excluded for failing to follow task instructions. This means that they failed to answer the questions (62), or failed an attentional check question (4). 205 participants were excluded from the analyses for failing to answer correctly 2 out of 3 comprehension questions for either of the vignettes. The remaining sample was composed of 149 participants (aged 18-75; (69 female; 2 prefer not to answer). Mean age 38.93 (SD = 12.28). Ethics approval for this study was obtained from the [blanked] Human Research Ethics Committee. Informed consent was obtained from all participants prior to testing. The survey was conducted online using Qualtrics.

*3.1.2 Materials and Procedure*

All participants begin by reading three vignettes and answering three comprehension questions about each vignette.

**Universe E: Dynamically Ordered Universe (Growing Block)**

Imagine a universe (Universe E) where new events and objects constantly come into existence. The events and objects that come into existence remain in existence, so the sum total of reality grows as new events and objects come to exist. In this universe we can generate an ordering of events in terms of the coming into existence of new events and objects. Some scientists, philosophers and theologians in Universe E think that the set of events and objects that have just come into existence are those that are in the present. They think that as new events and objects come into existence, already existing events and objects become part of the past. They think that no future events and objects exist.

For example, in Universe E there are two particles, P1 and P2. In this universe, there is an event of P1 hitting a particle detector, and an event of P2 hitting that particle detector. When the event of P1 hitting the detector has just come into existence, the event of P2 hitting the detector does not exist; but when the event of P2 hitting the detector has just come into existence, the event of P1 hitting the detector exists.

So some scientists and philosophers in this universe think that when P1’s hitting the detector has just come into existence, P2’s hitting the detector is future and does not exist, and when P2’s hitting the detector has just come into existence, P1’s hitting the detector exists, and is past. In this universe the ordering of events that is generated via the coming into existence of new events and objects has a single, correct, direction. In this case, it goes *from* P1’s hitting the detector, *to* P2’s hitting the detector (not from P2’s hitting the detector to P1’s hitting the detector).

Participants then saw three comprehension questions:

(1) "Scientists in Universe E think that the present is real, but the past and future are not."

(2) "Scientists in Universe E think that the present moves as new events come into existence."

(3) "Scientists in Universe E think that the present is just whichever time one is at. Every time is present to the individuals located at that time."

**Universe D: Non-dynamically Ordered Universe (C-theory)**

Imagine a universe (Universe D) where a single set of events exist. All these events are equally real. The sum total of reality never grows or shrinks, so the totality of events that exist never changes. These events bear certain relations to one another and these relations between events in Universe D are fixed and never change. It is possible to order the events in that universe in terms of these relations. Some scientists, philosophers and theologians in Universe D call these relations of *betweenness*. In Universe D no set of events is special, in that every event is present from the perspective of those located at it, just as every location is ‘here’ from the perspective of those located at it.

For example, in Universe D there are three particles, P1, P2, and P3. In this universe, there is an event of P1 hitting a particle detector, and an event of P2 hitting that particle detector, and an event of P3 being deflected from the particle detector. The event of P1 hitting the particle detector is *between* the event of P3 being deflected from the particle detector, and the event of P2 hitting the particle detector. That relation never alters; it is always the case that the event of P1 hitting the particle detector is between the events of P2 hitting the detector, and P3 being deflected from the detector. In this universe the ordering of events generated by the betweenness relations does not generate a direction: there is no fact of the matter as to whether the ordering goes *from* P3’s being deflected from the detector, *to* P1’s hitting the detector *to* P2’s hitting the detector or, alternatively, *from* P2’s hitting the detector *to* P1’s hitting the detector, *to* P3’s being deflected from the detector. But some scientists, philosophers and theologians in Universe D think that from one perspective, P3’s being deflected from the detector occurs earlier than P1’s hitting the detector which occurs earlier than P2’s hitting the detector, and that from another perspective P2’s hitting the detector occurs earlier than P1’s hitting the detector, which occurs earlier than P3’s being deflected from the detector.

Participants then saw three comprehension questions:

(1) "Scientists in Universe D think that the present is real, but the past and future are not."

(2) "Scientists in Universe D think that the present moves from earlier times to later times. For instance, the present was once located in the year 1900, is now located in the year 2019, and will located in the year 2100."

(3) "Scientists in Universe D think that the present is just whichever time one is at. Presentness does not move from earlier times to later times. Every time is present to the individuals located at that time."

**Universe F: Unordered Universe (D-theory)**

Imagine a universe (Universe F) where a single set of events exists. All these events are equally real. The sum total of reality never grows or shrinks, so the totality of events that exist never changes. While all these events exist there is no correct way to order these events. Instead, Universe F is like a deck of cards. Each card represents all the events that bear purely spatial relations to one another. Purely spatial relations are relations such as Mike being three feet from Lily, or Boston being 16000kms from Sydney. In Universe F, the only distance relations that exist are spatial distance relations. So each ‘card’ represents all the events that are spatially separated from one another, and which bear no other distance relations to one another. Some scientists, philosophers, and theologians in Universe F are inclined to say that all the events ‘on the same card’ occur simultaneously. While there is a fact of the matter regarding the spatial relations between objects and events located on the same card, there is no fact of the matter as to the order of the cards. Any way of ordering the cards is just as good as any other way. Because of this, there is no fact of the matter about the distance relations between events on different cards.

For example, in Universe F there are three particles, P1, P2 and P3. In this universe, there is an event of P1 hitting a particle detector, an event of P2 hitting that particle detector, and an event of P3 being deflected by that particle detector. The event of P1 hitting the detector and the event of P3 being deflected from the detector bear spatial relations to each other. So there is a fact of the matter as to spatial distance between P1’s hitting the detector and P3’s being deflected by the detector. So we can say how far away P1 is, from P3, when each encounters the detector. As some scientists in Universe F would have it, these two events occur simultaneously. But the event of P2 hitting the detector does not occur simultaneously with either P1 hitting the detector or P3 being deflected by the detector. P2’s hitting the detector is, as it were, on a different card from P1’s hitting the detector and P3’s being deflected by the detector. So there is no fact of the matter regarding the distance between P1’s hitting the detector and P2’s hitting the detector, or between P3’s being deflected by the detector and P2’s hitting the detector. Nor is there any fact of the matter which order these events occur in. It is no more true to say that first P3 is deflected from the detector, and second, P2 hits the detector, than it is to say that first P2 hits the detector, and second, P3 is deflected by the detector. And that is true for all events in Universe F that are not simultaneous with one another. Any way of ordering non-simultaneous events is equally good.

Participants then saw three comprehension questions:

(1) "Scientists in Universe F think that there are no temporal distances between events."

(2) "Scientists in Universe F think that the present moves from earlier times to later times. For instance, the present was once located in the year 1900, is now located in the year 2018, and will located in the year 2100."

(3) Scientists in Universe F think that the past exists but the future does not."

After reading all three vignettes, participants were asked the question: “which universe do you think is most like our own” and are given three options: Universe D, Universe E, or Universe F. They are then asked to indicate their level of confidence in that judgement on a Likert scale of 1-7 where 1 is very unsure and 7 is very sure. Participants who answered two or more of the comprehension questions incorrectly, about any of the vignettes, were excluded from all of the analyses. At no point could participants return to a previous screen.

Participants then see two vignettes in random order, on different screens: vignette F (unordered) and vignette E (dynamically ordered). After each vignette is presented, participants are told to imagine that the actual universe has been discovered to be just like the universe in the vignette, and are presented with the statement “there is time in universe E/F” are asked how strongly they agree/disagree on a Likert scale of 1—7.

Participants then see both vignettes side by side. Half the participants are told that universe E is just like the actual universe, and universe F is a parallel universe, and half are told that universe F is just like the actual world, and universe E is a parallel universe. The instructions are as follows: “imagine scientists discover that the *actual*Universe (the one where you and I live) is exactly like Universe [**E|**F]. Now imagine scientists are suddenly able to observe a *parallel* Universe. The parallel Universe is like the actual universe in many respects: it contains many of the same things as our universe. However, the *parallel* Universe is exactly like Universe [E|**F**]. The scientists are right about this: the actual Universe is exactly like Universe [**E|**F] and the parallel Universe is exactly like Universe [E|**F**]. Imagining that is the case, please answer the following question about the *parallel* Universe. Remembering that the actual universe is just like Universe **[E|**F], and the parallel universe is just like Universe [E|**F]**.” Participants are then asked to indicate their level of agreement, on a Likert scale of 1-7, with the following statement: “there is time in the parallel universe.” They are then asked to indicate their level of confidence in their previous judgement.

**3.2 Experiment 2**

*3.2.1 Participants*

402 people participated in the study. Participants were U.S. residents, recruited and tested online using Amazon Mechanical Turk, and compensated $2 for approximately 20 minutes of their time. 50 participants had to be excluded for failing to follow task instructions. This means that they failed to answer the questions (44), or failed an attentional check question (6). 206 participants were excluded from the analyses for failing to answer correctly 2 out of 3 comprehension questions for either of the vignettes.

The remaining sample was composed of 146 participants (aged 18-72; (57 female; 2 prefer not to answer). Mean age 36.53 (SD = 12.14). Ethics approval for this study was obtained from the [blanked] Human Research Ethics Committee. Informed consent was obtained from all participants prior to testing. The survey was conducted online using Qualtrics.

*3.2.2 Materials and Procedure*

The procedure in experiment 2 was exactly the same as in experiment 1, except that after having seen all three vignettes participants are presented with a different pair of vignettes: a non-ordered vignetted (D-theory) and a non-dynamically ordered vignette (C-theory vignette). *Mutatis mutandis*, all other aspects of methodology were the same.

3.3Results

*3.3.1. Experiment 1*

Table 1, below, presents the descriptive data of experiment 1. The ‘Yes’ column indicates the proportion of participants who responded with either 5, 6, or 7 when asked their level of agreement that there is time in the scenario being evaluated; the ‘No’ column represents the proportion of participants who responded with either 1, 2, or 3. The ‘4’ column is the proportion of people who neither agree nor disagree that there is time in the scenario being evaluated. The mean is the mean level of agreement that there is time in the scenario being evaluated. In order to test whether the mean response significantly differed from 4 in each condition we ran separate one-sample t-tests for each condition for each group. If the mean is significantly above 4, then overall people might think that there is time in the condition; if the mean is significantly below 4 then overall people might think there is *no* time in the condition; if the mean does not differ significantly then overall people might be indifferent. We say ‘might’, here, since means can be misleading: there can be a mean of significantly above 4 in some condition, and yet it still be the case that a *majority* of participants judge that there is no time in that condition.

*Table 1.* *Levels of agreement* *that there is time in scenarios taken as actual or counterfactual. In parentheses we note how the actual world is taken to be when making the judgement about the counterfactual world.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|   | **%Yes** | **%No** | **%4** | **Mean** | **SD** | ***t*-value** | ***p*-value** |
| **Group: Growing Block is most like the actual world (*N* = 109; 73.2%)** |
| Actual Growing Block | 92.7 | 5.5 | 1.8 | 5.98 | 1.24 | 16.690 | <.001 |
| Counterfactual Growing Block (Actual D-Theory) | 84.4 | 12.8 | 2.8 | 5.51 | 1.55 | 10.201 | <.001 |
| Actual D-Theory | 30.3 | 65.1 | 4.6 | 3.26 | 1.76 | -4.406 | <.001 |
| Counterfactual D-Theory (Actual Growing Block) | 36.7 | 59.6 | 3.7 | 3.56 | 1.89 | -2.429 | .017 |
| **Group: C-Theory is most like the actual world (*N* *=* 25; 16.8%)** |
| Actual Growing Block | 88 | 12 | 0 | 5.48 | 1.26 | 5.862 | <.001 |
| Counterfactual Growing Block (Actual D-Theory) | 64 | 24 | 12 | 4.96 | 1.59 | 3.012 | .006 |
| Actual D-Theory | 52 | 48 | 0 | 3.92 | 2.06 | -0.194 | .848 |
| Counterfactual D-Theory (Actual Growing Block) | 36 | 56 | 8 | 3.64 | 1.85 | -.975 | .339 |
| **Group: D-Theory is most like the actual world (*N* = 15; 10.1%)** |
| Actual Growing Block | 66.6 | 26.7 | 6.7 | 4.93 | 1.79 | 2.018 | .063 |
| Counterfactual Growing Block (Actual D-Theory) | 53.3 | 46.7 | 0 | 4.13 | 2.07 | .250 | .806 |
| Actual D-Theory | 46.7 | 33.3 | 20 | 4.33 | 1.92 | .774 | .511 |
| Counterfactual D-Theory (Actual Growing Block) | 46.7 | 33.3 | 20 | 4.47 | 1.69 | 1.073 | .301 |

The way to read this table is as follows. The first row is what the dynamical orderists (those who think the growing block scenario is most like our world) say about whether there is time in an ordered scenario (a growing block world) considered as actual. In effect, then, this is to ask them whether they think there is time in the actual world, given what the way they in fact take our world to be. There, we see that 92.7% of dynamical orderists think there is time in the actual world, given that it is as they suppose it to be, dynamically ordered, and that the mean level of agreement that there is time in that world of 5.98 is statistically significantly above 4. The second row tells us what dynamical orderists say about there being time in a growing block scenario considered as counterfactual, conditional on them being asked to suppose that in fact, the actual world is D-theoretic. So here, people who in fact think our world is dynamically ordered, are asked to suppose that they discover it to be D-theoretic (unordered) and then are asked to evaluate whether there is time in a counterfactual growing block scenario. There, we see that 84.4% of dynamical orderists think there is time in the counterfactual growing block scenario, conditional on the actual world being a D-theoretic world, and that the mean level of agreement that there is time in that scenario is 5.51, which is statistically significantly above 4. The third row tell us what dynamical orderists say about whether there is time in a D-theoretic scenario considered as actual: that is, do they think that actually, there is time if they are told that it has been discovered that in fact our world is D-theoretic? There, we see that only 30.3% of dynamical orderists think there is actually time under this supposition, and the mean levels of agreement that there is time in the scenario is 3.26, which is statistically significantly below 4. The rest of the able is to be read in the same way, except that in the next section of the table we are focussing on the judgments of non-dynamical orderists, and, below that, the judgements of non-orderists.

Three of our predictions are ones we can speak to by looking to table 1. First, as we predicted, a very small percentage of participants were non-orderists. In fact, there were only 15 non-orderists, or ~10% of the population. Second, we predicted that amongst dynamical orderists, mean levels of agreement that there is time in an ordered scenario would be statistically significantly above 4 (neither agree nor disagree). This is vindicated: the mean level of agreement that there is time in the actual ordered scenario is 5.98, and that there is time in the counterfactual ordered scenario is 5.51, both of which are significantly above 4. Third, we predicted that amongst dynamical orderists, mean levels of agreement that there is time in an unordered scenario would be statistically significantly below 4. That prediction is also vindicated. Mean levels of agreement that there is time in an actual unordered scenario were 3.26, and in a counterfactual unordered scenario were 3.56, and both of these were significantly below 4. Of course, some caution is required when interpreting these results given the small number of non-orderists.

We also made a number of predictions about the majority of participants that would make one judgement or another in various conditions. We predicted that a majority of non-orderists would judge that there is time in both an actual and counterfactual unordered scenario. By contrast, we predicted that a majority of orderists would judge that there is no time in an actual or counterfactual unordered scenario. The results in table 1 go some way towards determining whether those predictions were supported. That table tells us what percentage of participants answered ‘Yes’ to the prompt question, and which answered ‘No’. Those results still leave some questions unanswered. For instance, suppose we find that 55% of people judge that there is time in some scenario, and 45% either judge that there is not time, or neither agree nor disagree that there is time. Is this split between these two populations statistically significantly different from a 50/50 split? That is, is this really a case in which a statistically significant *majority* makes the former judgement?

To test this, we ran separate one-way χ***2*** tests for each condition for each group (see Table 2 below). To do this we divided the population into those who responded that there was time in the scenario (Yes) and those who said that there was not (No) or who said that they neither agreed nor disagreed that there was time (4). We then asked whether the split between these two populations—Yes, and No/4—was statistically significantly different from a 50/50 split.

*Table 2. Proportion of participants who responded that there was time in the scenario (Yes) and those who said that there was not (No) or who said that they neither agreed nor disagreed that there was time.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **%Yes** | **%No/4** | χ***2***  | ***p*-value** |
| **Group: Growing Block is most like the actual world** |
| Actual Growing Block | 92.7 | 7.3 | 79.349 | <.001 |
| Counterfactual Growing Block (Actual D-Theory) | 84.4 | 15.6 | 51.606 | <.001 |
| Actual D-Theory | 30.3 | 69.7 | 16.963 | <.001 |
| Counterfactual D-Theory (Actual Growing Block) | 36.7 | 63.3 | 7.716 | .005 |
| **Group: C-Theory is most like the actual world** |
| Actual Growing Block | 88 | 12 | 14.440 | <.001 |
| Counterfactual Growing Block (Actual D-Theory) | 64 | 36 | 1.960 | .162 |
| Actual D-Theory | 52 | 48 | .040 | .841 |
| Counterfactual D-Theory (Actual Growing Block) | 36 | 64 | 1.960 | .162 |
| **Group: D-Theory is most like the actual world** |
| Actual Growing Block | 66.7 | 33.3 | 1.667 | .197 |
| Counterfactual Growing Block (Actual D-Theory) | 53.3 | 46.7 | .067 | .796 |
| Actual D-Theory | 46.7 | 53.3 | .067 | .796 |
| Counterfactual C-Theory (Actual Growing Block) | 46.7 | 53.3 | .067 | .796 |

From table 2 we see that only 46.7% of non-orderists judge that there is time in the actual, or counterfactual unordered world. Rather than being a *majority* of participants, as we predicted, this appears to be a *minority*. The χ***2*** test suggests, however, that the split between those who think there is time in those scenarios, and those who judge either no, or 4, is not significantly different from a 50/50 split. Again having said that, some care is needed in working with the one-way χ***2*** results amongst the non-orderist population given the very small sample size. Nevertheless, what seems clear is that the hypothesis is not supported. At best the population is split: a statistically significant majority do not judge that there is time in those scenarios.

That is interesting, since these are participants who think that our world is in fact D-theoretic, and so who presumably judge that there is not actually time. So a substantial proportion of non-orderists respond as though they take the presence of an ordered substructure of instants to be absolutely necessary for time, while a substantial proportion respond as though the presence of such a structure is neither absolutely nor conditionally necessary for there to be time.

Moving on, we predicted that a majority of dynamical orderists would judge that there is no time in an unordered scenario, regardless of whether they were evaluating it as actual or as counterfactual. This prediction was vindicated. 30.3% of dynamical orderists judge that there is time in an actual unordered scenario, and 36.7% judge that there is time in a counterfactual unordered scenario. The one-way χ***2*** test shows that the split between the two populations (yes vs no/4) is significantly different from a 50/50 split.

Lastly, we predicated that, amongst dynamical orderists, mean levels of agreement that there is time in an ordered scenario would be significantly higher than mean levels of agreement that there is time in an unordered scenario, and we predicted that there would be no statistically significant differences between orderists’ judgements regarding whether there is time in an unordered scenario considered as actual or considered as counterfactual.

 In order to speak to the remainder of our hypotheses we ran a 2x2 repeated measures ANOVA amongst the dynamical orderists.[[12]](#footnote-12) Results of this ANOVA found a main effect of theory being evaluated *F*(1, 108) = 149.160, *p* < .001, and a significant two-way interaction between theory being evaluated and context of evaluation *F* (1, 108) = 18.147, *p* < .001.The main effect of theory being evaluated showed that levels of agreement were significantly higher when evaluating the growing block (M = 5.75, SD = 1.25) than for the D-theory (M = 3.41, SD = 1.71).

Hence, as predicted, amongst dynamical orderists mean levels of agreement that there is time in an ordered scenario are significantly higher than mean levels of agreement that there is time in an unordered scenario.

Simple effects tests with a Bonferroni correction were carried out on the two-way interaction between theory being evaluated and context of evaluation. First, when evaluating the growing block universe, levels of agreement were significantly higher when considered as actual (M = 5.98, SD = 1.24) than when considered as counterfactual (M = 5.51, SD = 1.55; *p* < .001). Second, when evaluating the D-theory, levels of agreement were significantly higher when considered as counterfactual (M = 3.56, SD = 1.89) then when considered as actual (M = 3.26, SD = 1.76; *p* = .015). Third, when considered as actual, levels of agreement were significantly higher when evaluating the growing block than when evaluating the D-theory (*p* *<* .001). Fourth, when considered as counterfactual, levels of agreement were significantly higher when evaluating the growing block then when evaluating the D-theory (*p* < .001).

Hence the prediction that there would be no statistically significant differences between orderists’ judgements regarding whether there is time in an unordered scenario considered as actual, or considered as counterfactual, was not supported. There was a slight, yet significant, difference: dynamical orderists have higher levels of agreement that there is time in scenarios considered as counterfactual when compared to scenarios considered as actual.

*3.3.2. Experiment 2*

*Table 3.* *Levels of agreement* *that there is time in scenarios taken as actual or counterfactual. In parentheses we note how the actual universe is taken to be when making the judgement about the counterfactual scenario.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|   | **%Yes** | **%No** | **%4** | **Mean** | **SD** | ***t*-value** | ***p*-value** |
| **Group: Growing Block is most like the actual world (*N* = 91; 62.3%)** |
| Actual C-Theory | 50.5 | 42.9 | 6.6 | 4.07 | 1.73 | 0.363 | .717 |
| Counterfactual C-Theory (Actual D-Theory) | 48.3 | 46.2 | 5.5 | 3.98 | 1.85 | -0.113 | .910 |
| Actual D-Theory | 28.6 | 68.1 | 3.3 | 3.15 | 1.75 | -4.611 | <.001 |
| Counterfactual D-Theory (Actual C-Theory) | 30.8 | 63.7 | 5.5 | 3.25 | 1.76 | -4.047 | <.001 |
| **Group: C-Theory is most like the actual world (*N* *=* 39; 26.7%)** |
| Actual C-Theory | 87.1 | 10.3 | 2.6 | 5.69 | 1.24 | 8.532 | <.001 |
| Counterfactual C-Theory (Actual D-Theory) | 82 | 15.4 | 2.6 | 5.28 | 1.56 | 5.148 | <.001 |
| Actual D-Theory | 69.2 | 30.8 | 0 | 4.72 | 2.06 | 2.172 | .036 |
| Counterfactual D-Theory (Actual C-Theory) | 76.9 | 20.5 | 2.6 | 4.87 | 1.81 | 3.010 | .005 |
| **Group: D-Theory is most like the actual world (*N* = 16; 11.0%)** |
| Actual C-Theory | 68.7 | 12.5 | 18.8 | 4.88 | 1.67 | 2.098 | .053 |
| Counterfactual Growing Block (Actual D-Theory) | 68.7 | 31.3 | 0 | 4.44 | 1.83 | 0.959 | .353 |
| Actual D-Theory | 81.2 | 18.8 | 0 | 5.50 | 1.75 | 3.426 | .004 |
| Counterfactual D-Theory (Actual C-Theory) | 87.5 | 12.5 | 0 | 5.56 | 1.26 | 4.948 | <.001 |

This second experiment replicated some, but not all, the results of our first experiment. First, as in experiment 1, we found a small percentage (~11%) of non-orderists amongst the population. The prediction that amongst dynamical orderists, mean levels of agreement that there is time in an ordered scenario would be statistically significantly above 4 was not, however, vindicated. Remember, in this case dynamical orderists are evaluating a *non-dynamical* (C-theoretic) ordered scenario, whereas in experiment 1 they were evaluating a dynamical (growing block) scenario.

The mean level of agreement that there was time in the ordered scenario considered as actual or counterfactual, were not, however, significantly different from 4: overall, people neither agreed nor disagreed that the non-dynamically ordered scenario was one that contained time. We also predicted that amongst dynamical orderists, mean levels of agreement that there is time in an unordered scenario would be statistically significantly below 4. This prediction was vindicated: in both the counterfactual and actual unordered scenario, mean levels of agreement were significantly below 4.

 That brings us our predictions about what the majority of participants in our sub-populations would judge. We predicted that a majority of non-orderists would judge that there is time in both an actual and counterfactual unordered scenario. We also predicted that a majority of dynamical orderists would judge that there is no time in an actual or counterfactual unordered scenario. Table 4, below, shows the results of the separate one-way ***χ2*** tests.

*Table 4. Proportion of participants who responded that there was time in the scenario (Yes) and those who said that there was not (No) or who said that they neither agreed nor disagreed that there was time.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **%Yes** | **%4/No** | ***χ2*** | ***p*-value** |
| **Group: Growing Block is most like the actual world** |
| Actual C-Theory | 50.5 | 49.5 | .011 | .917 |
| Counterfactual C-Theory (Actual D-Theory) | 48.4 | 51.6 | .099 | .753 |
| Actual D-Theory | 28.6 | 71.4 | 16.714 | <.001 |
| Counterfactual D-Theory (Actual C-Theory) | 30.8 | 69.2 | 13.462 | <.001 |
| **Group: C-Theory is most like the actual world** |
| Actual C-Theory | 87.2 | 12.8 | 21.564 | <.001 |
| Counterfactual C-Theory (Actual D-Theory) | 82.1 | 17.9 | 16.026 | <.001 |
| Actual D-Theory | 69.2 | 30.8 | 5.769 | .016 |
| Counterfactual D-Theory (Actual C-Theory) | 76.9 | 23.1 | 11.308 | .001 |
| **Group: D-Theory is most like the actual world** |
| Actual C-Theory | 68.8 | 31.3 | 2.250 | .134 |
| Counterfactual C-Theory (Actual D-Theory) | 68.8 | 31.3 | 2.250 | .134 |
| Actual D-Theory | 81.3 | 18.8 | 6.250 | .012 |
| Counterfactual C-Theory (Actual C-Theory) | 87.5 | 12.5 | 9.000 | .003 |

Recall that in experiment 1 our prediction that a majority of non-orderists would judge that there is time in both an actual and counterfactual actual unordered scenario was not vindicated. In this experiment, however, it is. Over 80% of non-orderists judged that there is time in an actual unordered scenario and counterfactual unordered scenario, and this majority is significant when measured against a 50/50 split. The second prediction was also supported. A majority of dynamical orderists judge that there is no time in an actual unordered scenario (71.4%) or a counterfactual unordered scenario (69.2%) and this is a significant majority.

 To test the remaining hypotheses we ran a 2x2 repeated measures ANOVA, which found a main effect of theory being evaluated *F*(1, 90) = 20.812, *p* < .001. The main effect of theory being evaluated showed that levels of agreement were significantly higher when evaluating the C-theory (M = 4.02, SD = 1.64) than for the D-theory (M = 3.20, SD = 1.60). No other significant main or interaction effects were observed.

 This means our prediction that amongst dynamical orderists mean levels of agreement that there is time in an ordered scenario would be significantly higher than mean levels of agreement that there is time in an unordered scenario was supported. Contrary to experiment 1, so was our hypothesis that there would be no statistically significant differences between mean levels of agreement of dynamical orderists’ judgements regarding whether there is time in an unordered scenario considered as actual or as counterfactual.

4. Discussion

Most of the results from experiment 2 replicate those from experiment 1, despite the fact that in the two experiments they were evaluating two different kinds of ordered scenario.

In general we found that amongst dynamical orderists, a majority judge that the presence of an ordered substructure of instants is absolutely necessary for there to be time, and a minority judge that the presence of ordering relations is neither absolutely nor conditionally necessary for there to be time. While experiment 1 found there to be some small difference in dynamical orderists’ responses to scenarios considered as counterfactual as opposed to actual, it did not find that these participants think that ordering relations are necessary only if actual: insofar as there was any effect, participants were more inclined to agree that there was time in the *counterfactual* unordered scenarios than the actual ones. So these results provide no reason to think that these participants employed concept(s) on which the presence of an ordered substructure of instants was conditionally necessary for time.

Given that dynamical orderists are a large percentage of the population as a whole, (and given the distribution we find amongst the other two much smaller sub-populations) we can conclude that amongst the population sampled, a majority have folk concept(s) on which the presence of an ordered substructure of instants is absolutely necessary for time.

The two experiments diverge, however, when we look at the responses of the non-orderists. In experiment 1 we found that ~50% of the population judge that there is *no* time in unordered actual and counterfactual scenarios, while in experiment 2 a large majority judged that there *is* time in unordered actual and counterfactual scenarios.

So experiment 1 suggests that a majority of non-orderists have folk concept(s) on which the presence of an ordered substructure of instants is absolutely necessary for time. If that is true, then, at least in this regard, non-orderists agree with orderists: they both think that the presence of an ordered substructure of instants is absolutely necessary for time, they just disagree about whether actually there is an ordered substructure of instants (and hence disagree about whether actually, there is time).

Experiment 2, however, suggests that a majority of non-orderists have folk concept(s) of time on which the presence of ordering relations is *neither* absolutely *nor* conditionally necessary for time. If that is so, then the majority of non-orderists *disagree* with the majority of (dynamical) orderists about whether the presence of ordering relations is necessary, in any sense at all, for there to be time.

This disparity between experiments 1 and 2 might seem surprising. On reflection, however, given the very small number of non-orderists in each experiment, it isn’t: it only takes a few non-orderists to respond differently in one experiment compared to another, and that small number will be enough, in a small sample size, to change which judgements the majority make. This means that we cannot speak to whether a majority of non-orderists have a concept on which the presence of an ordered substructure of instants is absolutely necessary, or a majority have a concept on which the presence of an ordered substructure of instants is not necessary at all. What seems clear is that *some* non-orderists certainly have one concept, and some have the other, but because there are so few non-orderists in the population, these two experiments cannot tell us any more than that. So in what follows we don't want to place too much weight on the particular responses of this small group of people. In particular, we don’t think that we can learn much about these people’s concept(s) of time by these empirical findings.

 In all, then, what do these results tell us about the conditions under which our folk concept of time is likely to be unsatisfied, and hence temporal error theory is likely to be vindicated, and what do they tell us about whether strongly timeless theories really are *folk* timeless? Our data suggests that strongly timeless theories eliminate folk time for the majority of the population we tested. For most people, the presence of an ordered substructure of instants in a world is *absolutely* necessary for time. This is important. It means that one way for most people’s folk concept(s) to fail to be satisfied is for there to fail to be an ordered substructure of instants. In turn, that means that one way to vindicate folk temporal error theory (at least for most of the population) is if a theory is vindicated according to which there is no such ordered substructure of instants.[[13]](#footnote-13) Notice that it matters, for the purposes of vindicating folk temporal error theory, that most people have folk concept(s) on which the existence of an ordered substructure is *absolutely* necessary for time: if, instead, they had concept(s) on which the presence of an ordered substructure is only *conditionally* necessary—necessary only if actual—then the discovery that there is actually no ordered substructure would *not* be the discovery that those concept(s) are unsatisfied, and hence would not be the discovery that, for a majority of people, folk temporal error theory is true. So had a majority of people had concept(s) on which the presence of an ordered substructure is only conditionally necessary for time, it would not have followed that strongly timeless theories eliminate folk time. As it happens, though, our results show that strongly timeless theories do eliminate folk time.

What implications are there of our discovery that strongly timeless theories eliminate folk time? We noted earlier that there appears to be a connection between the non-existence of folk time and the non-existence of causation, agency, persistence and personal-identity. That is because, even setting aside folk concepts of causation, agency, etc., our *philosophical* accounts of these notions are explicated, in part, in terms of time and temporal relations (for more on this see Baron, Miller and Tallant forthcoming).

 One possibility is that it’s not merely contingent that we explicate those notions in terms of temporal notions, but rather, that it is essential to some, or all, of them that we do so. It might be that there are no *timeless* notions of causation, agency, persistence and personal-identity, to be had. Suppose that is so. Then our work here shows that the following conditional is true: if a strongly timeless theory is true, then there is no agency, causation, persistence or personal-identity. Faced with the truth of this conditional one has two options.

The first option is to accept the truth of the antecedent, and hence, also, the truth of the consequent. If one takes there to be strong independent scientific evidence in favour of a strongly timeless theory, then this might seem like the right way to proceed. But notice that this is a very radical position indeed. The conclusion that we are not agents or persons, that there is no causation or persistence, strikes us as somewhere between incredible and ludicrous. This would not be the discovery that agency is somewhat different than we thought; it would be the discovery that things like you and I are just not the kinds of things that deliberate about what do, are causally efficacious in bringing things about, are extended in time with a life that has a temporal narrative, and so on. So we take this option to be startling indeed.

The second option is to deny the antecedent, which leaves one free to deny the consequent as well. There are two ways one might proceed to do so. One might take there to be scientific evidence against any strongly timeless theory, which is evidence that is independent of any considerations pertaining to agency, causation etc. Alternatively, one might attempt to argue from the falsity of the consequent to the falsity of the antecedent. That is, one might argue that since patently we are agents and persons, and since patently there is persistence and causation, then there must be (folk) time, and hence any theory according to which there is no folk time must be false. We take this latter form of argumentation to be startling, in that we find it surprising that consideration of our natures as agents and persons would give us reason to reject some theory of quantum gravity. As we see it, then, if this conditional claim is true then we should really hope that there is good scientific evidence against strongly timeless theories. Otherwise we are left trying to argue against such theories by appealing to the fact that we are agents (etc.) or trying to make sense of the fact that we are not agents (etc.) We don't want to take a stand on which way one should go on this issue: but clearly our results have implications for the sorts of consideration that ought be borne in mind when assessing strongly timeless theories.

 Of course, in order to get to either of those conclusions we’ve made an assumption along the way: namely that folk time is indispensable to any account of causation, agency, personal-identity and persistence, and so if folk time is eliminated then so too are these other things. That assumption might be false. So another way forward, in light of our empirical results, is to develop timeless accounts of causation, persistence, agency and personal-identity. Then if some strongly timeless theory turns out to be true it will follow that folk time is eliminated, but causation, persistence, agency and personal-identity need not be.

 So while our studies go some ways towards addressing a number of important issues in this area, there are others that await further research. In particular, we really need to know whether folk time is necessary for the existence of causation, persistence, agency and personal-identity. That is not something these studies address. But they do tell us that if folk time is necessary for these phenomena to obtain, then the truth of a strongly timeless theory undermines *all* of these notions.

 Even if you think that the antecedent of the conditional is false, because you think there is no good scientific evidence for the truth of a strongly timeless theory, we hope that this research is interesting nonetheless. As we noted earlier, philosophers of time have appealed in various ways to the folk concept of time. Not all philosophers think that all of these appeals are legitimate. Nevertheless, it would be nice to know something about the content of the folk concept in evaluating those arguments that we do think are legitimate, and perhaps even in responding to those that we don’t. This paper doesn’t provide anything like a complete account of the content of the folk concept(s) of time. But it does tell us something about one key aspect of those concept(s): namely that there is a necessary condition shared by most of those concepts, regarding how the world needs to be if they are to be satisfied. That, at least, is the beginnings of an explication of those concept(s). Clearly though, much more work would need to be done in this area; this is just the beginning.

5. Conclusion

We hope to have gone some way towards spelling out one condition under which folk temporal error theory is (for most of us) vindicated. In the process we also hope to have gestured towards some further research that explores the connections between the folk concept of time, and related concepts of causation, agency, and personal-identity.

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43:223–241.

1. For discussion of the general issue of space-time emergence in such theories see also Lam and Oriti (2018), Lam and Esfeld (2013) and Crowther (2016). For related discussion see Anderson (2017) and Gomes (2018). Other approaches to this problem have been to embrace what has become known as space-time functionalism, according to which we ‘functionalise’ space-time (we say what it would be for something to pay tat role) and then we find things, at the fundamental level, that do play that role. See for instance Lam and Wuthrich (2018). Still others have argued that there are approaches on which, in fact, temporal structure is fundamental (Gryb and Thebault (2016)). [↑](#footnote-ref-1)
2. Of course it could be that the folk concept is satisfied only if there is such a substructure, and that substructure is fundamental. But at this stage of enquiry we see little reason to suppose this to be so. [↑](#footnote-ref-2)
3. And perhaps only if: we take no stand on this. [↑](#footnote-ref-3)
4. See Baron, Cusbert, Farr, Kon, and Miller (2015). [↑](#footnote-ref-4)
5. For arguments of this kind see Zimmerman, (2008) Smith (1994), Craig (2000) and Schlesinger (1994). [↑](#footnote-ref-5)
6. For ways of discharging this burden see Ismael (2012); Callender (2017); Miller, Holcombe and Latham (2018). [↑](#footnote-ref-6)
7. It is in many ways misleading to say that presentists believe that there is substructure of ordered instants, since they deny there is any dimension along which such instants can be ordered. Still, they clearly think that instants are ordered, insofar as there is a fact of the matter as to which order instants ‘occur’ in. For our purposes this sort of order is sufficient. [↑](#footnote-ref-7)
8. Sometimes people use ‘B-theory’ synonymously with ‘block universe theory’, and, as such,

this view does not entail that time has a direction. However, that usage makes little sense of the debate between B-theorists and C-theorists, (nor is it faithful to McTaggart’s (1908) introduction of the terms) or the debate amongst B-theorists, regarding in virtue of what time has a direction. At any rate, we intend to use ‘B-theory’ to pick out the view that time has a direction, regardless of whether or not this is standard usage. [↑](#footnote-ref-8)
9. This is not, then, how McTaggart (1908) thought of the C-series. [↑](#footnote-ref-9)
10. As for instance, presentists surely do not. [↑](#footnote-ref-10)
11. See Latham (2019) and Roskies and Nichols (2008). [↑](#footnote-ref-11)
12. Repeated measures ANOVA are used to compare the means of 3 or more groups when the participants in those groups are the *same*. The ANOVA tells us whether the means are statistically significantly different between those groups. We ran a two-way (2x2) repeated measures ANOVA because there were *two* independent variables (theory being evaluated and context of evaluation). [↑](#footnote-ref-12)
13. That is not to say, of course, that there might not be lots of other ways to vindicate folk temporal error theory: it is just that we cannot speak to those here. [↑](#footnote-ref-13)