From Timeless Physical Theory to Timelessness

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ABSTRACT

This paper addresses the extent to which both Julian Barbour's Machian formulation of general relativity and his interpretation of canonical quantum gravity can be called timeless. We differentiate two types of timelessness in Barbour's (1994a, 1994b and 1999c). We argue that Barbour's metaphysical contention that ours is a timeless world is crucially lacking an account of the essential features of time—an account of what features our world would need to have if it were to count as being one in which there is time. We attempt to provide such an account through considerations of both the representation of time in physical theory and in orthodox metaphysical analyses. We subsequently argue that Barbour's claim of timelessness is dubious with respect to his Machian formulation of general relativity but warranted with respect to his interpretation of canonical quantum gravity. We conclude by discussing the extent to which we should be concerned by the implications of Barbour's view.

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1. Introduction

It is now ten years since Julian Barbour first introduced his rather revolutionary views about the fundamental structure of our world to a general audience, and it is fair to say that although his views have been well scrutinised by the theoretical physics community, they have largely been ignored by the

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philosophical community.[1] This is a pity, since the analysis that Barbour provides of this particular attempt to unify general relativity and quantum mechanics is rich in startling metaphysical consequences. He argues that ours is a timeless world: the apparent experience of change, persistence and motion, of memory and anticipation, are *merely* apparent. There is no unique way our world was in the past, nor will be in the future. There is just a static configuration space filled with three dimensional 'instants' and no path through that space that can rightly be thought as a history of a world. This is a radical conclusion that would seem to overhaul almost all that we think we know about the world.

Barbour's project is multifaceted: beginning with his reformulation of general relativity and using canonical quantisation techniques to yield a particular representation of canonical quantum gravity, Barbour proposes a picture of the fundamental structure of reality through his interpretation of these physical theories. Taking the technical details of this project as given, it is worth considering whether some of the radical metaphysical conclusions that Barbour draws really are a consequence of this proposed picture of reality. We begin, in section 2, by offering an exploration of Barbour's views. This allows us, in section 3, to consider the extent to which Barbour's view entails that our world has no time. In order for Barbour to extract a metaphysical conclusion from his physical picture, a further premise about the nature of time is required. In particular, we need a premise that states the necessary features of time, and we need these necessary features to be ones that Barbour's physical picture tells us that our world lacks. We consider two possible ways to understand the essential features of time: through an analysis of the representation of time in physical theory, on the one hand, and in terms of more orthodox metaphysical analysis, on the other. We argue that on either way of construing the essential features of time only one arm of Barbour's project is genuinely timeless. Finally, in section 4, we consider some outstanding worries with Barbour's view if we take his conclusion seriously. In particular we consider two issues: first we consider whether his account of the experience of time, motion and change is a good one; and second we consider a worrying sceptical scenario that may be entailed by his view. We argue that although this scepticism arises, it is not as pernicious as one might have supposed.

[1] Some notable exceptions include Butterfield 2001, Healey 2002 and Ismael 2002.

2. Exploring Barbour

Barbour's interpretation of canonical quantum gravity is presented both in his (1999c) and in a pair of companion papers which preceded it (1994a, 1994b) and is best understood as comprised of two major parts. The first part consists of an argument that classical general relativity can be formulated in a Machian, and thus in some sense timeless, fashion. The key to this argument is the claim that general relativity is an implementation of a dynamical theory (with dynamic geometry) that can be formulated as a reparametrisation invariant geodesic principle on the relative configuration space of all possible instants of time. In the second part of his project, Barbour examines a theory of quantum gravity constructed via the quantisation of this formulation of general relativity, his interpretation of which is itself also timeless. The key to this second part is the proposal that the Wheeler-DeWitt equation, the timeless dynamical law of canonical quantum gravity, can be interpreted as a probability distribution, defined in terms of the relative configurations, that concentrates the quantum mechanical probability on 'time capsules'. Importantly for our purposes in this paper, the sense in which Barbour's Machian formulation of general relativity is timeless differs in some crucial respects to the sense in which his interpretation of quantum gravity is timeless; more on this to follow. Firstly, let us begin characterising Barbour's position in more detail by considering the structure of configuration space.

According to classical mechanics, the objects of the universe at any particular instant are in some definite configuration relative to one another. It is usual to refer to any one of these configurations as an instant of time. While the notion of an instant loses some of its physical significance in relativity theory (since an instant is a hyperplane or hypersurface in a four dimensional spacetime, and specification of these in relativity theory is arbitrary), this significance is regained when describing dynamical evolution: the essence of dynamics is to describe the evolution of specific data on such hyperplanes or hypersurfaces. The dynamical evolution of a particular physical system can be formulated in terms of a configuration space Q which represents all the successive configurations through which the system passes as it evolves in time. The path that a system describes through its Q is a path of least action, or *geodesic*, where the action is a function of the energy of the system and the physical laws governing the dynamical evolution; this is the Hamiltonian formulation of a physical theory.

In taking the system in question to be the universe, one can move from the configuration space of the universe Q to a relative configuration space of the universe Q_0 by factoring out the six frame variables that specify the centre-of-mass coordinates and the orientation of the system; thereby one can remove any absolute frame from the description of the universe. The formulation then of a relational theory of dynamics requires that we define the action between any two neighbouring points of Q_0 in terms of the best-matching of the intrinsic differences between the two points in question, quantified by a Pythagorean least-squares fit; this is the essence of a Machian formulation of a physical theory. Barbour describes this process as like placing two relative configurations on top of each other and then supposing them moved relative to each other until the intrinsic difference between them is least. Via this Machian definition of the action, geodesics through Q_0 can be obtained.

Barbour claims that general relativity is a special case of such a Machian formulation of a physical theory where the instants of time in the relative configuration space are no longer configurations of particles in Euclidean space but three dimensional Riemannian spaces endowed with 3-geometries. The sense in which such a Machian theory is timeless is the following:

> time [... is] obtained from a timeless[...] ‘heap’ of relative configurations [...] by ‘placing’ the configurations on top of each other in the best-matching positions (*horizontal stacking* [...]) and ‘spacing them apart’ (*vertical stacking*) in accordance with their [...] differences. (Barbour 1994a, p. 2863)

Thus, while time is not present in any individual three dimensional relative configuration, the Machian principle on the relative configuration space enables time to be reconstructed as an ordering of the instants along a geodesic. Barbour contends that the fundamental property of general relativity is that it is a timeless theory of the relationships of 3-geometries and the relative configuration space is the arena in which we should fundamentally describe reality.[2] With this Machian notion of timelessness in mind, let us turn to the second part of Barbour’s project, his timeless interpretation of canonical quantum gravity.

Canonical quantum gravity is a theory of quantum gravity that is obtained from the Hamiltonian formulation of general relativity and canonical quantisation techniques. Thus while in some sense Barbour’s interpretation of

[2] Barbour’s Machian formulation of general relativity is not without its technical problems. See Pooley 2001.

canonical quantum gravity is inescapably connected to the Hamiltonian formulation of general relativity, the timelessness of the former is not related to the Machian sense of timelessness of the latter. To see this, let us consider how Barbour's interpretation grows from the sort of union he envisages between general relativity and quantum theory. If the arena for our fundamental classical description of reality is the relative configuration space as above, then the compatibility of quantum theory with this description is dependent upon the viability of formulating quantum theory in terms of instantaneous relative configurations of systems. Barbour notes that the time independent quantum dynamical laws *can* be represented on a space of three dimensional relative configurations; the Schrödinger wavefunction of any system is defined over all its possible configurations, and thus instead of describing a unique classical history in the configuration space of the system, the quantum wavefunction explores all configurations. If we were then to extend the relative configuration space, on which the time independent Schrödinger equation is usually applied, to the relative configuration space of the universe, Barbour suggests that the Wheeler-DeWitt equation could be used to describe a static wavefunction Ψ that takes relative configurations as its argument.

On this view, the notion of a Hilbert space representing the state space of some subsystem of the universe is simply redundant; Barbour proposes to treat the universe as a single holistic quantum system. In any one configuration, no distinction is possible between quantum system and measurement device: all are simply part of a particular configuration of the universe. The sole role of the wavefunction, as in Born's probability interpretation, is to say how likely the actualising of a given configuration is. These probabilities are not, however, time dependent nor are they conditioned on prior knowledge and tied to measurement setups; they are given once and for all for the possible configurations that the universe could be in. It is in this sense that Barbour's interpretation of canonical quantum gravity is timeless.

In trying to motivate an intuitive picture of his model, Barbour contrasts two ways that we might imagine such a universe: externally and internally (1994b, p. 2881). From an external viewpoint, we can imagine each relative configuration of the space to exist as a *heap of possibilities*.[3] We can then divide the space into infinitesimal hypercubes, take the value of Ψ in each

[3] Barbour emphasises that this is called a 'heap' because each point in the relative configuration space has, unlike an ordinary manifold, an individual existence outside the space, i.e., a three dimensional configuration.

hypercube, calculate $\Psi\Psi^*$ and place a number proportional to $\Psi\Psi^*$ of identical copies of a representative configuration of that hypercube into a second heap called the *heap of actualities*.[4] We may now suppose that drawing one configuration at random from the heap of actualities actualises that configuration. Thus, a probable configuration is more likely to be actualised than one that is improbable.

From an internal viewpoint, we have it that our direct experience, including that of motion, is correlated only with configurations in our brains.

> Our seeing motion at some instant is correlated with a single configuration of our brain that contains, so to speak, *several* stills of a movie that we are aware of at once and interpret as motion. (Barbour 1994b, p. 2883)

The connection between the internal and external views is that while some "divine mathematician" actualises (by random selection) one particular configuration of the universe, it seems to us as though we are inside part of that configuration and have direct awareness of that part as an experienced instant. The problem in orthodox quantum theory concerning the reality of the unactualised possibilities is compounded in Barbour's quantum gravity

> since one even has to ask whether events of which we have vivid memories are actually experienced. This is because everything we experience in any instant, including the memories themselves, must be coded in our instantaneous brain configuration. Records of apparent past events are in fact details in the present configuration. And all the timeless theory tells us is that each such configuration has a certain probability. (Barbour 1994b, p. 2883)

Thus while we have direct evidence that the present configuration is actualised, we are epistemically locked in this configuration and therefore have no warrant for believing that any other instant is actually experienced. Barbour's quantum gravity «does seem to come perilously close to solipsism of the instant» (Barbour 1994b p. 2883).

The most significant element of Barbour's interpretation of quantum gravity is the notion of a time capsule. A time capsule is a static configuration of part or all of the universe containing structures which suggest they are mutually consistent records of processes that took place in a past in accordance with certain laws. It is the existence of such special configurations that Barbour

[4] In what way we are to imagine this heap of actualities is unclear. We abstain from exploring this issue.

claims allow us to recover the appearance of time from a timeless reality. Since the set of all time capsules has negligible measure amongst the set of all possible configurations, Barbour's proposal is conditional upon his suggestion that the solution to the Wheeler-DeWitt equation concentrates the quantum probability distribution on time capsules, thereby making it probable that we would find ourselves in a three dimensional configuration that contained evidence of having been created by a dynamical process. With this, then, the moral of the second part of Barbour's project is that «time is not a framework in which the configurations of the world evolve [rather] time exists only so far as concrete configurations express it in their structure» (Barbour 1994b, p. 2885).

3. Locating Barbour

For those more familiar with work in the philosophy of time, Barbour's claim of timelessness may seem startling: it is not immediately obvious how or why such a conclusion should follow from Barbour's treatment of classical general relativity or his interpretation of quantum gravity. Thus while we leave the task of challenging the technical details of Machian general relativity and canonical quantum gravity to Barbour's fellow physicists, we pose here a challenge of a different sort. If Barbour's two theories are indeed fair descriptions of the classical and quantum worlds respectively, what does this tell us about time in our universe? In particular, should we conclude that ours is a timeless universe?

One might begin by asking how we find ourselves in a position to decide that some particular phenomenon, class of phenomena or kind of object does not exist; after all, we do not discover absences. In the case of phenomena that are posited by scientific theories, we usually decide that the posits are unreal if we find that (i) the theory that posits them is false, (ii) there is no true theory whose posits are sufficiently like those of the original theory and (iii) we are not inclined to say that the posits of the former just are the posits of the latter appropriately reconstrued. For instance, when the theory that posited phlogiston is found to be false we become error theorists about phlogiston. Had the posited features of phlogiston been sufficiently like those of oxygen in crucial ways we might instead have discovered that there is phlogiston but it is somewhat different than we first thought. Many philosophers are tempted to say that this same story can be applied to terms that are not introduced via scientific theories but are the folk terms we find in everyday discourse. Thus they are inclined to say that we became error theorists about witches because we discovered that the "folk theory" that posited witches was false and no close successor of the theory was true (and hence we did not discover that witches were rather different than we had supposed). put in broad terms, one might say that one will become an error theorist about the *x*s, just in case the core or essential claims about the nature of the *x*s (whether these are part of scientific theory or folk theory) turn out to be false.

According to Barbour we ought to be error theorists about time. If he is right, this must be because certain core or essential claims about the nature of time turn out not to be true. It now becomes clear why his conclusion might seem startling: for although Barbour offers an interesting reformulation of general relativity and a solid interpretation of the formalism of canonical quantum gravity, he says very little about what our universe would need to be like for it to be a universe in which there is time; he does not characterise time's essential features. The crucial link in the argument for timelessness therefore appears to be missing: namely the link that takes us from the claim that particular features are essential to time to the claim that in virtue of Barbour's classical and quantum theories those features are absent, and thus to the conclusion that there is no time.

Thus in this section we explore two routes for characterising the essential features of time. The first route, section 3.1, proceeds via the features of time as they are represented in physical theory while the second route, section 3.2, is a consideration of the features of time as one might find them in more orthodox metaphysical analyses. Through these considerations of the essential features of time we hope to offer some suggestions for filling the aforementioned lacuna in Barbour's own argument for timelessness. We then evaluate the extent to which Barbour's argument thus construed is compelling.

Before we embark on this examination let us introduce some terminology that will help us distinguish the different senses of timelessness in Barbour's work that we wish to highlight below. The core of Barbour's claim of timelessness is that the fundamental elements of our description of reality, both in his classical theory and his quantum theory, are *three* dimensional relative configurations, i.e., frozen instants of time which lack a temporal dimension. However, as we noted above, there is a significant difference between the timelessness of Barbour's Machian formulation of general relativity and the timelessness of his interpretation of canonical quantum gravity. In the former sense, the timelessness of the relative configurations is supplemented by a Machian reconstruction of temporal structure: using only the data present within the set of relative configurations we can reconstruct reparametrisation invariant geodesics through Q_0 and thus we can read off a temporal metric from these geodesics. As Butterfield remarks, the Machian formulation of general relativity «will deserve to be called 'timeless', in that there is no time metric in Q_0; rather [...] the time metric is definable from the dynamics» (Butterfield 2001, p. 15). Thus while the theory is timeless in the sense that a time dimension is absent from the fundamental elements of the theory, a temporal metric of sorts can be reconstructed from these timeless elements. Let us call this Machian timelessness.

The same cannot be said of the latter sense of timelessness. The timelessness of Barbour's interpretation of canonical quantum gravity is again manifest in the absence of a time dimension in the fundamental elements of the theory but, in contrast to Machian timelessness, it is then compounded by the further structure in the theory: there exists a time independent (static) quantum probability distribution (QPD) across the relative configuration space that is concentrated upon time capsules, i.e., special three dimensional configurations that merely *appear* as though they have been created from a dynamical process. Thus in quantising the Machian formulation of general relativity to yield Barbour's particular interpretation of quantum gravity we lose an element of Machian temporal reconstruction and gain an account of temporal appearances in the form of time capsules. Let us call this sense of timelessness QPD timelessness. Barbour does not provide a clear statement distinguishing these two senses of timelessness. Indeed, Butterfield again, «the book [The End of Time] gives the misleading impression that Barbour's various views are closely connected one with another» (Butterfield 2001, p. 3). The distinction between these two senses of timelessness will become more clear through our consideration of the essential features of time.

3.1. Representing time in physical theory

According to Rovelli, when we use the word 'time' there are many attributes of time to which we might be referring. Indeed, in both his (1995) and his (2004), Rovelli identifies up to nine distinct attributes of time that we find littered throughout our contemporary physical theories and folk concepts, including directionality, uniqueness and globality amongst others. Rovelli's project concerning the notion of time is a terminological one: in identifying these different senses of time, he might begin to alleviate some of the ambiguity that abounds in the philosophy of physics literature. We wish to utilise this prescription to clarify Barbour's error theoretic claim.

Rovelli proposes that our contemporary physical theories and folk concepts that refer to time can be arranged in a hierarchical structure in which an increase in universality corresponds to a decrease in the possible attributes of time to which we might be referring. Thus when we refer to time in orthodox general relativity, since it is one of our most universal physical theories, there are only two possible attributes of time to which we can be referring: linearity, 'time' can be used to refer to a one dimensional substructure of ordered temporal instants; and metricity, 'time' can be used to refer to the meaningful measure of distance between any two time instants. Given the focus on these two features of time in general relativity, we can characterise the essential features of time that Barbour might be denying as just these features: linearity and metricity. This now gives us a straightforward manner in which to evaluate Barbour's claim that both his Machian formulation of general relativity and his interpretation of quantum gravity entail that we live in a timeless world: in each case we consider the extent to which linearity and metricity can be extrapolated from Barbour's interpretations of the relevant physical theories.

In Barbour's Machian formulation of general relativity and his interpretation of canonical quantum gravity the fundamental elements of the theory are three dimensional relative configurations. If we consider a single relative configuration in isolation, there is no one dimensional substructure therein to identify as time and no way to meaningfully measure the temporal distance from this configuration to any other. Thus in both his classical and quantum theories, when we consider a single instant in the relative configuration space, we notice that there is no fundamental linear or metric structure to be found.

However, an integral part of Barbour's Machian formulation of general relativity is the specific and detailed Machian algorithm that enables one to define a meaningful measure of distance between any two points in the relative configuration space and thus describe a linear ordering of instants along a geodesic, thereby recovering both linearity and metricity. Thus when it comes to Barbour's Machian formulation of general relativity, these two particular features of time are not entirely absent from the theory. The relevant features exist, it is just that they emerge out of the three dimensional points in the relative configuration space via this specific best-matching algorithm. Thus it becomes apparent that talk of time is not misplaced in Barbour's Machian general relativity; there is time *qua* linearity and metricity, it is just that time is not a fundamental component of the theory, admitting of a straightforward reduction to the relative configuration space.

Given this reduction, it would be very odd for Barbour to claim, with respect to his Machian formulation of general relativity, that time ought to be eliminated from our ontology. This is because this sort of reduction about some phenomenon is rarely a reason to eliminate the reduced phenomenon from our ontology, except in cases where there is an essential feature of the phenomenon to be reduced that is not captured by its putative reductive base. However this is clearly not the case here: the relative configuration space of Barbour's formulation of general relativity explicitly yields a temporal parameter that corresponds directly with that of orthodox general relativity. Thus it appears that Barbour's claim that his Machian formulation of general relativity is timeless involves a touch of hyperbole. For Barbour, his formulation of general relativity is timeless simply because time is not fundamental; it is not, however, timeless because time does not exist.

Is it possible to strengthen Barbour's argument here turning his Machian timelessness into a more full-blown error theory about time? Well, one option might be for Barbour to claim that being one of the fundamental posits in our best physical theory is essential to the nature of time. If this conceptual claim were true then it would seem that a more robust error theoretic conclusion would follow from the fact that no fundamental linear or metric structure is present in the theory.

Even if this were correct, however, it seems to us that there is a ready response available on behalf of the temporal realist: namely, that it is not at all obvious that it is part of our conceptual grasp of the notion of time that, whatever time is, it is fundamental in the sense that it is posited by the most fundamental physical account of our universe. It might be that time is fundamental in the sense that we find ourselves unable to imagine being able to engage in ordinary talk without appealing to temporal relations, and unable to imagine what it would be like to experience the world without experiencing it in terms of temporal relations, but that is not at all to say that we suppose it essential to time that it is physically fundamental.

Another option for turning Barbour's Machian formulation of general relativity into a robust error theory might be via some form of an indispensability argument. These arguments are familiar, particularly in the philosophy of science. They generally proceed via the claim that we ought to be ontologically committed to all and only the entities indispensable to our best scientific theories. Indispensability, in this context, is replacing the Quinean idea that we regiment our best scientific theories in first-order logic and in so doing reveal their ontological commitments. Rather, the idea is that we should be committed to those entities that are indispensable to those theories, where an entity is indispensable to a theory just in case, roughly, a nominalised version of the theory (one that does not quantify over the entity in question) is less theoretically virtuous than the non-nominalised version.

With this in mind, one might attempt to use the following argument to bolster Barbour's view:

(i) Time does not play a role in the Machian formulation of general relativity.
(ii) If time does not play a role in the Machian formulation of general relativity, then time is dispensable from one of our most basic physical theories.
(iii) If time is dispensable from one of our most basic physical theories then we ought not to be committed to the existence of time.
(iv) Therefore, we ought not to be committed to the existence of time.

Although this would give Barbour his error theoretic conclusion, it seems to us that this argument is sound only if we ought to be committed not only to all of the indispensable posits of our best scientific theories, but to *only* those posits. However, this is a controversial claim: some philosophers are tempted to think that our ontological commitments should be broader than science alone allows (i.e., Lewis' commitment to the existence of concrete possible worlds).

In addition, the argument is sound only if we are committed to all and only the posits of *fundamental physics*. But again, this is controversial. Higher level theories commonly quantify over temporal phenomena (like instants). For example, theories of meteorology, economics, psychology, and likely some higher level theories of physics itself. And it is not at all clear that talk of time can be eliminated from such theories without a loss of theoretical virtue. If that is right, then quantifying over time is not dispensable to our best theories broadly construed. Indeed, instead we seem to find that we ought to be committed to the existence of time. Only if we ignore these other theories and focus on fundamental physics should we conclude that there is no time. But if we do that then we should also conclude that most of the ordinary objects in our common sense ontology do not exist, since they are dispensable to fundamental physical theory. Since that seems too much to be plausible it may not be the right set of theories to take into account when we are trying to figure out what exists. But once we take into account the right set of theories, the claim that time is dispensable may seem less obvious, and with it the conclusion that we should be temporal error theorists may seem less compelling.

If what we have said so far is along the right lines, then it is hard to see how Barbour might successfully argue for an error theoretic conclusion based only on his Machian interpretation of General Relativity. When it comes to Barbour's interpretation of canonical quantum gravity, however, it seems that Barbour makes a much stronger case for an error theory. This is because, unlike Barbour's Machian formulation of general relativity, there is no algorithm specified for defining a meaningful measure of distance between the relative configurations and thus there is no linear ordering of the three dimensional instants; there is only the appearance of an illusory history from within each time capsule. What this shows us is that QPD timelessness is genuine timelessness in the error theoretic sense: not only is it the case that there is no linear or metric structure in the theory, such structure is not recoverable from the relative configuration space in any sense. At best, there is the mere illusion of linear and metric structure via the time capsules.[5]

Thus, it is only QPD timelessness and not Machian timelessness that gives Barbour the sort of error theoretic conclusion that he seems to want. This is important because, as we shall now show, this interpretation of the difference between Machian timelessness and QPD timelessness in terms of the representation of time in physical theory dovetails nicely with what we take to be the most plausible metaphysical interpretation of the difference between these two senses of timelessness. Indeed, both the physical and metaphysical interpretations suggest that it is only QPD timelessness that is genuine timelessness.

3.2. Time in metaphysics

In the preceding discussion we considered one particular route towards characterising the essential features of time, i.e., as they are represented in

[5] For an interesting discussion of structure that might be associated with the set of time capsules, see Healey 2002.

physical theory. In this section we pursue an alternate route to this end in terms of more orthodox metaphysical analyses. Metaphysicians have long worried about what sorts of features might be essential to time and, by considering some widely held views in the metaphysics of time, we can begin to assess the extent to which these views might be appropriate for filling the lacuna in Barbour's argument for timelessness. In fact, we will see below that these two routes we consider are actually not so different; the metaphysical characterisation of the essential features of time we present here corresponds closely to the characterisation we presented in the previous section. One might even go so far to say that the following metaphysical analysis is a mere terminological variant of the argument in terms of the temporal structure of physical theory (more on this below).

McTaggart's famous distinction between the A-series and the B-series will be familiar to most (1908). The A-series and the B-series constitute two distinct ways of ordering times, events and so on. The B-series orders times in terms of the relations of earlier than, later than and simultaneous with. These relations are taken to be unchanging. That is, for any two times (or any two events) t_1 and t_2 in some world *W*, if t_1 and t_2 are related by some B-theoretic relation, *R*, then they are *R*-related from the perspective of any time in *W*. Or, as it is commonly described, t_1 and t_2 are "tenselessly" related in *W*. The A-series, by contrast, orders times in terms of whether they are objectively past, present or future.

The easiest way to get a handle on the A-series is in terms of the monadic properties of pastness, presentness and futurity. The idea is that for any time in the A-series, that time instantiates a particular A-theoretic property that determines its place in that series. So, for example, suppose that there are two times t_1 and t_2 that are located in the A-series. On this view, their location in the A-series will be determined by the monadic properties they instantiate. Thus, t_1 might instantiate the monadic property of pastness (say), and t_2 might instantiate the monadic property of presentness. Unlike the B-series, however, the monadic properties that t_1 and t_2 instantiate are dynamic. That is, it is usually thought that if t_1 instantiates the property of presentness, then it will eventually instantiate the property of pastness with the passage of time. Indeed, some A-theorists are inclined to think that t_2 becomes more past as the monadic property of the present shifts from one time to the next. Regardless, this shift in A-theoretic properties is usually attributed to the objective flow of time and marks the principle difference between the A-series and the B-series.

The B-theory of time is the view that once we have laid down the B-series, we have thereby completed our description of time. The A-theory, by contrast, is the view that the B-series constitutes an incomplete description of temporal reality. In order to complete this description we must also accept the reality of the A-series.

Given this distinction, there are really two routes to a temporal error theory. Almost everyone supposes that if there is an A-series in a world, then there is also a B-series in that world, but that the presence of a B-series does not entail the presence of an A-series. Thus one might take the A-series to be essential to time (as A-theorists do) and think that actually there is no A-series, thus concluding that actually there is no time. Or one might think that the B-series is essential to time (as B-theorists do) and think that actually there is no B-series (and thus also no A-series), thus concluding that actually there is no time. Or one might think that it is essential to time that there is either an A- or a B-series, but that actually there is neither, and thus actually there is no time. The last two of these options effectively collapse into one, since regardless of whether one thinks that either the A- or the B-series is necessary for the existence of time, or one thinks that the B-series alone is necessary for the existence of time, since the absence of the B-series in a world entails the absence of the A-series in that world[6], in either case a world without the B-series is a world without time. Thus we consider just the first and second of these options since the second entails the third.

Is either of these routes to error theory one that Barbour intends? It should be clear from section 2 that the physical picture he proposes is incompatible with the existence of an A-series. He denies that the world is dynamical in the way that A-theorists think it to be: there is merely the static state of the configuration space, nothing comes into being or passes from being, and nothing comes to be the present that was past and will be future.

[6] The A-theorist may contest this conceptual claim. In particular, they may object to the implication that the B-series is necessary for the existence of the A-series. Rather, the A-theorist might contend that the A-series is, in some sense, metaphysically primitive and it is the A-series that is, in fact, necessary for the existence of the B-series. If this is the case, then *contra* what we say below, endorsing a view according to which there is no A-series would entail a robust error theory about time. Nevertheless, given that Barbour does not discuss the A-theory in any great detail, it is unlikely that this is what he means by the claim that there is no time. Still, there are some interesting issues here: what is the right conceptualisation of time? And what implications does it have for standard metaphysics? Unfortunately, we do not have the space to go into these issues in detail here.

So if Barbour thought that the A-series were essential to temporality, then his error theoretic conclusion would follow. But if this were all there were to his view, it would not be very startling. After all, most physicists hold that the A-series is incompatible with our best physics and that, as a result, there is no actual A-series. If this were Barbour's view, then although he might offer a substantially new physical theory, his claims about temporal error theory would not issue from any particular features of that new theory, but merely from the well canvassed fact that modern physics offers us a B-theoretic conception of our universe that makes little room for the features posited by the A-theorist.

Moreover, if that were Barbour's route to error theory, it would not, we think, be a particularly compelling one. For suppose there were a world with a B-series and no A-series. Then in that world there are events related by earlier and later than relations, and indeed related by temporal durations (at least relative to any given frame). It still makes sense to talk about when an event happened, and what happened at the same time (though not in a frame invariant manner) and it makes sense to make appointments at certain times in the future, and to anticipate those future events and to wish they were happening sooner. Thus it seems entirely open to someone to respond to such an error theorist by arguing that she has misunderstood the folk concept of time, and by doing so has invested that notion with essential features, namely the A-theoretic features, that the folk notion simply never had. The presence of the B-series, she will maintain, is sufficient for the existence of time since there are perfectly good relations of earlier and later than and so forth and these are sufficient to make it the case that our everyday term 'time' refers. Thus if Barbour's view were simply that ours is not an A-theoretic world, and thus that temporal error theory follows it would seem entirely plausible to respond that the B-theory is all that is necessary for temporality and that ours is a B-theoretic world.

Fortunately, Barbour's claim that there is no time is not, we think, best interpreted as the claim that the A-series does not exist. Rather, it seems more plausible to read him as holding that it is essential to time that there is a B-series, and that since actually there is no such series, there is actually no time. Such a view is considerably more interesting since the case for temporal error theory is much stronger if one supposes that actually there is no B-series. For one might reasonably hold that if there are no relations of earlier and later than or simultaneous with, then truly there are no temporal relations and hence no time.

We can see just how this way of understanding Barbour provides some insight into his claim that our world is a timeless one. Consider again the distinction made above between Machian timelessness and QPD timelessness. As noted above, Barbour's Machian formulation of general relativity contains a detailed algorithm for reconstructing four dimensional spacetime from the three dimensional relative configurations. This reconstruction of spacetime yields a reconstruction of a temporal ordering, and thus a B-series. If we read Barbour's claim of timelessness as error theoretic about the B-series, Machian timelessness simply does not fit this bill.

Having said this, QPD timelessness provides a more conducive timeless structure: there is no temporal ordering whatsoever in Barbour's interpretation of quantum gravity, reconstructed or not. The appearance of the present configuration having evolved in time is merely an illusion brought about by the mutually consistent records we find in each time capsule. Thus it seems as though all that exists are the set of instants that neither bear B-type relations to one another, nor instantiate A-type monadic properties. If that were right, then in some sense Barbour would hold a similar view to McTaggart. According to McTaggart, neither the A-series nor the B-series exists. All that exists is what he calls the C-series, which is not a temporal series *per se*, since the C-series is a series of times that are not related by the temporal relations of earlier than, later than and simultaneous with, nor are they related by the A-theoretic determinations of pastness, presentness and futurity. Indeed, both McTaggart and Barbour would agree that if there is no B-series, no objective temporal ordering whatsoever, then plausibly there is no time. So if Barbour implicitly takes the B-series to be essential to time, and since his interpretation of quantum gravity entails that there is no such series, then we think his error theoretic conclusion is warranted with respect to QPD timelessness.

As mentioned at the beginning of this section, the parallel between the argument in section 3.1 concerning the temporal structure of physical theory and the metaphysical argument presented here suggests a close correspondence between the two. In both analyses we find that in Barbour's Machian formulation of general relativity certain essential features of time remain as integral parts of the theory: a linear and metric temporal structure, on the one hand, and a B-series, on the other. Put like this, however, it should now be clear why there is a close correspondence between these two arguments: the temporal structure that the B-series provides just is a linear and metric temporal structure, and *vice versa*.[7] Thus, one might say, the above metaphysical analysis is a terminological variant of the argument developed in section 3.1. It should come as no surprise then that via both routes for characterising the essential features of time we find Barbour's error theoretic conclusion dubious with respect to his Machian formulation of general relativity but warranted with respect to his interpretation of canonical quantum gravity.

4. TIME CAPSULES, TEMPORAL EXPERIENCE AND SOLIPSISM

So far we have considered the extent to which Barbour's claim of timelessness is compelling. Suppose, however, we accept that Barbour gives us some reason to endorse an error theory of time. In this section we wish to examine the position in which this leaves us. In particular, focusing on Barbour's interpretation of canonical quantum gravity, we consider two issues. First, we will assess Barbour's attempt to provide an account of why it is that we experience motion and change given that nothing moves and nothing changes. And, second, we will then consider a sceptical worry with Barbour's view concerning the ontological status of points in the relative configuration space.

4.1. ON THE EXPERIENCE OF MOTION AND CHANGE

There are really two components to Barbour's metaphysical view of time as it pertains to his interpretation of canonical quantum gravity. The first component consists in the claim that time is unreal. It is this feature of the view that has been the focus of the discussion thus far. The second component is the claim that change and motion are unreal. Arguably, this second claim falls out of the first: if there is no time, then nothing can change and nothing can move. This is because, we suppose, it is something of a conceptual truth about change and motion that they require time.

This second feature of Barbour's view is startling. In experience it seems to us that things change and that things move. However, Barbour's view entails that these experiences are systematic illusions: although we experience motion

[7] Likewise, the temporal structure that the A-series provides might also be characterised in terms of Rovelli's attributes of time: linearity, metricity, globality, externality, uniqueness, directionality and presentness.

and change, these experiences are non-veridical, on a par with hallucinations. But as with any error theory this view incurs an explanatory cost: Barbour must provide us with some explanation as to why it is that we nevertheless seem to experience motion and change even though there is no motion or change in the world. Barbour recognises this explanatory burden and attempts to provide an account of such experiences via the central notion of a time capsule.

According to Barbour, time capsules are points in the configuration space that possess a rich structure of what we would describe as records: fossils, memories, geological phenomena and historical accounts of the past. Of course, for Barbour these are not, strictly speaking, records of 'the past' since there is no sense in which there is an objective past from the perspective of any point in the relative configuration space. As indicated, these records taken together merely constitute a mutually consistent story. This story, however, is a fiction and should not be taken to represent how things 'actually were' since, again, there is no way things actually were.

Now, for Barbour, our experience of change and motion is due to a specific kind of structure found in a time capsule: memories (or perhaps apparent memories, since they are only genuine memories if the events they are memories of did in fact happen in the past). Consider a film. There is an obvious sense in which the experience of motion and change when watching a film is an illusion. Films consist of a series of static frames that are replaced one after another at a certain speed such that it seems to us as though each frame is moving smoothly into the next. Barbour's explanation of why we experience motion or change proceeds along similar lines. Our experiences are the result of a huge series of experiential "stills", namely apparent memories, which are interpreted by our brains as the experience of motion and change.

It is unclear to us the extent to which one should think that Barbour offers a reasonable account of the appearance of motion and change within a timeless world. Here is a very quick argument that one might mount in response to Barbour's account of the experience of motion and change: everyone admits that we experience the phenomena of change; but you might think that in order to experience change, our experiences themselves must change (or, alternatively, our brains must undergo change as part of the process of interpretation); but either of those can be the case only if there is change in the world; so if we experience change then there is actually change.

Whether or not this argument is sound is contentious. In particular, it relies on claims about the nature of experience that we are not in a position to defend. Nevertheless, it is worth noting that if the argument is sound then this provides some evidence against the metaphysical claim that actually there is no time. This can be shown by way of the following further argument: it is obvious that we experience change in the actual world, the experience of change presupposes the existence of change and motion, in order for there to be change and motion in the world there must be time, therefore we do not live in a timeless world.

Even so, without this metaphysical claim, do we have good reason to give up on Barbour's particular physical theories? Well, it depends upon which arm of Barbour's interpretive project we are interested in. If we are focusing on his Machian formulation of general relativity then it is not clear that it does since, as indicated, there is no reason to think that this view is error theoretic about time. If, on the other hand, we are interested in his interpretation of quantum gravity, then since the non-existence of time is entailed by the theory, the above argument may give us some reason to doubt this interpretation.

It is worth noting that if Barbour does find the above argument worrying, then he has at least two options available. First, he might defend his account of motion and change by appealing more directly to the philosophy of temporal consciousness where a view along these lines has long been defended by a number of philosophers.[8] Second, he might prefer instead to reject the conceptual entailment between the existence of motion and change in the world and the non-existence of time. That is, he might argue that although time does not exist, there nevertheless is motion and change in some sense. Note that although strange, this manoeuvre resembles the sort of conceptual shift that occurred with regard to the A- and B-theories of time. According to McTaggart there could be no change or motion in a world in which there was no A-series. Subsequent to this, however, philosophers have found McTaggart's view to be implausible, maintaining instead that the B-series is sufficient for the existence of change, so-called Cambridge change. Perhaps then what Barbour's view shows us is that a similar conceptual shift is in the offing: contrary to what we might have thought, the B-series is not, in fact, necessary for the existence of change.

[8] This view is traditionally attributed to Husserl given in a series of lectures between 1893 and 1917, but has been more recently discussed by Barry Dainton 2000. See also Phillips 2008, Noe 2006 and Kelly 2005 for further discussion.

4.2. On solipsism

Another reason to find Barbour's view puzzling and perhaps worrisome is the concern that it might lead to temporal solipsism: the view that only a single moment exists, or will ever exist. Strictly speaking, Barbour's view is not a form of temporal solipsism. According to Barbour, the relative configuration space that is constitutive of the metaphysical structure of the universe is such that each and every point in the configuration space exists. A temporal solipsist formulation of Barbour's view would be the claim that only one point in the relative configuration space exists (or will ever exist), a claim that Barbour denies.

If Barbour's view is not a form of temporal solipsism, then what threat does temporal solipsism pose for his metaphysics? The trouble is that on Barbour's view we are epistemically locked within a single point in the configuration space. This is because the only epistemic access we have to the world is via empirical evidence, which is all encoded within a single time capsule.

If this is the case, then it seems that we have no warrant for believing that the other points in the configuration space exist. Consider a relative configuration space Q_0 in which only a single point t exists. Suppose that t is a time capsule and thus has a rich structure of apparent memories, historical accounts and so on. Finally, suppose that at t there exists at least one observer O. Now consider a relative configuration space $Q_0{}^*$ such that every point in $Q_0{}^*$ exists. Suppose that in $Q_0{}^*$ there is a point in the space t^* such that t^* is just as rich as t with regard to mutually consistent records and t^* is the home of at least one observer O^*. By Barbour's lights, O experiences the world in exactly the same way that O^* experiences the world. Moreover, both O and O^* have precisely the same sort of empirical evidence available to them. As a result, O^* could have no *a posteriori* reason for thinking that she lives in a $Q_0{}^*$-type configuration space rather than a Q_0-type configuration space.

Could then O^* have some *a priori* basis for thinking that she lives in a $Q_0{}^*$-type configuration space? Well, there are two options here. First, Barbour might provide some reason for thinking that the points in a relative configuration space are somehow mutually dependent in an ontological sense, such that if one point in the configuration space exists, then all points in the configuration space exist and *vice versa*. The idea then would be that a Q_0-type configuration space is simply incoherent, given a correct specification of the metaphysical constraints on configuration spaces in general. The upshot would be that O^* could, conceivably, have a reason for thinking that she lived in a

$Q_0{}^*$-type configuration space, since there are only $Q_0{}^*$-type configuration spaces. Unfortunately, there is nothing in Barbour's view (at least as set out above) that would warrant this metaphysical claim. Moreover, more generally, it is hard to see why the points in a relative configuration space like Barbour's need be ontologically dependent in the manner needed to avoid the worry: ontologically sparse relative configuration spaces just do not seem to us to be *a priori* incoherent.

This brings us to the second way in which Barbour might provide O^* with some *a priori* reason for thinking that she lives in a $Q_0{}^*$-type configuration space. This option involves appealing to theoretical simplicity. The idea here is that a theory that entails the existence of a $Q_0{}^*$-type configuration space is theoretically simpler than a theory that entails the existence of a Q_0-type configuration space, since all of the points in the configuration space are on a par, ontologically speaking. The trouble with this, however, is that the appeal to parsimony cuts both ways. This is because a Q_0-type configuration space is, in fact, more parsimonious than a $Q_0{}^*$-type configuration space when it comes to relative ontological economy. This is because a Q_0-type configuration space is committed to a single instant only, whilst a $Q_0{}^*$-type configuration space boasts a lavish ontology of instants. As a consequence, it seems that the two views have different theoretic virtues when it comes to parsimony. However, it is very hard to see why one form of parsimony ought to be preferred over another and, as a consequence, there seems to be no way that an appeal to symmetry principles of this kind can provide any *a priori* reason for thinking that O^* lives in a $Q_0{}^*$-type configuration space rather than a Q_0-type space.

What this shows us then is that Barbour's view entails a sort of scepticism about whether or not we live in a world in which temporal solipsism is true. This is because there seems to be no *a posteriori* or *a priori* way for one to determine whether one lives in a $Q_0{}^*$-type configuration space or a Q_0-type configuration space. But if this is correct, then it would seem that one can never be warranted in believing in the existence of a point in the relative configuration space other than the point at which one is located.

The crucial issue here then is just how serious a threat this sceptical scenario poses for Barbour. That is, would it really matter if we were warranted only in believing in the existence of a single point in the relative configuration space? It seems to us that although temporal solipsism is a worrying doctrine, it does not carry any negative implications that are not already contained within Barbour's view. In order to see why, it is useful to consider a more standard formulation of temporal solipsism that makes no mention of configuration spaces. The easiest way to get a handle on this form of temporal solipsism is to consider a view commonly referred to in the metaphysics of time as presentism. According to presentists, only a single time exists. However, presentists also believe that the present moves via an ongoing process of the *ex nihilo* coming into, and going out of existence of time slices. Thus, although only one time is ever in existence it remains the case that there were other times that existed and there will be other times that will exist in the future.

Temporal solipsism of the garden variety can be arrived at by taking presentism and stripping away the claim that time flows. Thus, on this view, only a single time, the present, exists and it is not the case that other times existed, and it is not the case that there will exist other times in the future. All there is, was and ever will be is a single, unchanging instant. Temporal solipsism of this form is unattractive for at least four reasons. First, it goes against the common sense view of time. This is because presentism is usually taken to be the common sense view of time, and temporal solipsism entails that presentism as traditionally conceived is false. Second, temporal solipsism entails that all of our apparent memories are false memories, all of our historical records are false records and all of our fossil evidence is not evidence at all. This is because there never was a past. Third, according to temporal solipsism, we do not persist through time. The most worrying consequence of this feature of the view is that it turns out to be irrational to anticipate experiencing what seem to us to be future events, or to regret those things that we take ourselves to have done in the past. This is because there is no sense in which we will be located at the future times in question to undergo the relevant experiences, or that we were located at the past times in question, doing the relevant deeds. Fourth, one might maintain that if temporal solipsism is true then nothing moves or changes. Aside from the cost to common sense, the temporal solipsist owes us an explanation of why it is that we experience motion and change, and it seems that any such explanation must appeal to certain instantaneous structures that exist within the one existing time (such as memories).

But if this is why temporal solipsism is taken to be so worrying then temporal solipsism does not in fact render Barbour's view any more unattractive than it already is. This is because Barbour's view carries the same commitments as garden variety temporal solipsism. That is, Barbour's view entails that presentism is false, that our memories are only apparent memories, that we are ontologically (and, indeed, epistemically) locked to a single time *qua* point in the relative configuration space and thus that we do not persist through 'time' and, finally, that the experience of motion and change is an illusion that must be accounted for using instantaneous structures, i.e., apparent memories. Thus, it is not clear to us that it matters for Barbour's view all that much if only a single time in the relative configuration space exists. This is because the move to temporal solipsism carries with it no added disadvantages. Of course, the upshot is that Barbour's view turns out to be only as plausible as temporal solipsism of the garden variety, since the two views have similar commitments. But we take it that Barbour would simply bite the bullet on any such metaphysically peculiar consequences given his conviction that his view is the best way to understand the physical structure of the world.

5. Conclusion

We do not claim to have given the definitive account of the metaphysical consequences of Barbour's timeless view. On the contrary, all we hope to have achieved is the beginnings of an exploration into the intriguing picture of the fundamental structure of our reality that Barbour presents. We warn, though, that one should proceed with caution. The lesson of this examination is that, due to the multifaceted nature of Barbour's view, his claim of timelessness is not "one size fits all". While the timelessness of Barbour's interpretation of quantum gravity seems to hold up to scrutiny, the timelessness of Barbour's classical theory is somewhat questionable. Nevertheless, if there is any decent chance that Barbour's interpretation of quantum gravity is correct, it is startling indeed to realise that this would entail that ours is a timeless world, and that alone makes consideration of Barbour's views important. For it is hard to imagine a greater change in how we view ourselves and our world than the discovery that all that we thought had gone before us, our memories, our accomplishments and our regrets are all illusory, and that our dreams for the future, our plans, our decisions and our choices are in some good sense pointless. Our self conception as agents who are extended in time and whose choices today in part create who we will be tomorrow would be radically undermined by discovering that ours is a Barbourian world, and that would require a radical rethink of ourselves as ethical and prudential agents, a task that we leave for another time.

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