

# Chapter 6

## From Physical Time to Human Time

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**Abstract** Time as experienced is said to have several properties that the physical image of time lacks.

In this paper, I outline a strategy for bridging the gap between the time of everyday experience and the time of physics that treats the Block Universe as a non-perspectival view of History and shows how to recover the everyday experience of time as a view of History through the eyes of the embedded, embodied participant in it. I also address questions about whether features of our temporal experience like passage and flow are properly thought of as illusory, the temptation to reify these features in the absolute fabric of the universe, and the question of whether this strategy takes passage seriously.

**Keywords** Temporal experience • Perspective • Passage • Flow • The openness of the future • Relativity • Block universe • *Sub specie aeternitatis* • McTaggart

Physics has forced us to revise our world-views in surprising ways and has also opened up new mysteries. The mysteries that get the most play outside of science are the mysteries at the frontiers of the physics of the very large and the very small. Almost everybody in the academy these days knows about quantum mechanics and the Higgs boson. Some may even know about Bell's Theorem. Everybody knows about black holes and dark matter. Some may even know about string theory and loop quantum gravity. These are the problems that tend to grab the popular imagination and also attract the attention of philosophers of physics. But some of the most difficult unsolved problems are much closer to the human scale and have to do with reconciling the way that physics tells us the universe *is* with the way that we experience it. So, for example, we do not have a good understanding of why time seems to have a direction, why the future seems different than the past, why time seems to flow, or even what this last thing means.

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29 Russell in the chapter entitled “The Abstractness of Physics” from *The Analysis*  
 30 *of Matter*, remarks on the distance that has grown between common sense and  
 31 physics:

32 From [its] happy familiarity with the everyday world physics has been gradually driven by  
 33 its own triumphs, like a monarch who has grown too grand to converse with his  
 34 subjects...

35 In another passage he likens physics and perception to a pair of friends walking  
 36 in conversation along opposite sides of a stream who don’t notice as the stream  
 37 gradually widens into a river so deep that they can no longer hear one another or get  
 38 across.<sup>1</sup> The traditional approach to reconciling the manifest image<sup>2</sup> of the world  
 39 with the image presented by physics is to focus on the logical relationship between  
 40 macroscopic and microscopic descriptions of the world. At first, high-level structures  
 41 like objects were assumed to be collections (‘mereological sums’, in the lingo)  
 42 of low-level objects in a given arrangement.<sup>3</sup> That idea turned out to be a little too  
 43 simple because the singular terms we apply at higher levels refer mostly to things  
 44 whose criteria of identity over time are not the criteria of identity for collections of  
 45 micro-level constituents. High level objects are, rather, configurations of low-level  
 46 objects that gain and lose parts but maintain enough internal integrity to be tracked  
 47 through change and reidentified across contexts.<sup>4</sup> This means that in order to know  
 48 which patterns are functionally suited to play the role of ‘objects’ (the macroscopic  
 49 things that we track visually and reidentify across contexts) at high levels of organi-  
 50 zation, it is not enough to know what the microscopic building blocks of matter are.  
 51 One has to also know what kinds of patterns emerge when large numbers of those  
 52 building blocks are put into interaction. Dynamics acquired a new importance in  
 53 understanding how these high-level structures are stabilized out of low-level inter-  
 54 actions, so formalizing the relationship between big things and little things, which  
 55 was at first conceived as the *a priori* philosophical project of giving the logic of the

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<sup>1</sup>“Physics and perception are like two people on opposite sides of a brook which slowly widens as they walk: at first is easy to jump across, but imperceptibly it grows more difficult, and at last a vast labor is required to get from one side to the other.” (Russel 1992, p. 137), thanks to Dustin Olson for tracking down the quote for me.

<sup>2</sup>I use ‘the manifest image of the world’, ‘the familiar world of everyday sense’, and ‘the world as we experience it’ interchangeably. There are some distinctions we might want to make between these but they won’t matter here. And I use the view of time *sub specie aeternitatis* and from a temporally transcendent perspective interchangeably.

<sup>3</sup>The properties of such things were known by their causal effects on macroscopic measuring instruments, and that raised issues about whether we had any direct grasp on the intrinsic properties of things. But structurally the macroscopic environment was thought to be a coarse-graining of the microscopic.

<sup>4</sup>A good example is provided by a wave moving across the surface of an ocean. The wave is a stable structure that can be identified and tracked as it moves towards shore. At any given time, it is wholly composed of water molecules, but there may be little or no overlap between the collection of water molecules of which it is composed at one time and that of which it is composed at another.

composition relation,<sup>5</sup> turned out to conceal a lot of interesting physics. The idea remained in place, however, that the manifest image is just a macroscopic coarse-graining of a universe described in microscopic detail by physics. And the difficulty was just trying to figure out which high-level configurations were going to be stable enough to act as targets for singular reference (i.e., to look suitably *thing-like* at the macroscopic level).

In prerelativistic days, *time* didn't seem to present any special difficulties. The time of Newton's physics was the dimension in which the History of the World unfolds, and it had the same dynamic character as our experience. But a whole new vision of time took shape with relativity that seemed to open a gap between the familiar time of everyday sense and time as it appears in physics. The new vision presented space and time together as a four-dimensional manifold of events, which came to be known as the Block Universe. In the Block Universe, there was no ontological difference between past, present, and future, and there was no process of coming into being. The universe simply *was*.

The difference between the familiar time of everyday sense and the Block Universe echoes an ancient debate between the Heraclitian and Parmenidean conceptions of the universe. The reaction against the new scientific image of time turned into a debate between two conflicting metaphysics: one that claims to have experience on its side, and one that claims to have physics on its side. Time as experienced is said to have four properties that the physical image of time lacks:

- (v) Asymmetry: there are dynamical asymmetries in the behavior of macroscopic systems that make it easy to distinguish a film of everyday macroscopic processes run forward from their temporal reverse;
- (vi) Flow: at any given moment, the world seems to be changing, or in flux;
- (vii) Passage: when we look back over our histories, we see that what was once future is now present, and what was once present is now past;
- (viii) Openness: at any given moment, there is one possible past and many possible futures.<sup>6</sup>

Giving explicit, non-metaphorical content to each of these properties is no easy matter. For historical reasons centering on the reduction of thermodynamics to the underlying microscopic theory, asymmetry became the focus of concerted attention in the foundations of physics. The topic remains one of the most active areas in foundational research. While there are many open questions, there has been a good deal of progress in finding a physical basis for the asymmetries that characterize the behavior of macroscopic systems. Passage and flow, by contrast, remain shrouded

<sup>5</sup>The name for this project was mereology, the theory of parts and wholes.

<sup>6</sup>Treat these as definitions that firm up terms that are often used loosely and interchangeably. 'Asymmetry' is often used to refer to any difference between past and future. I am using it to refer specifically to the dynamical asymmetries captured in the second law of thermodynamics. 'Passage' and 'flow' are often used interchangeably. As I use them, flow refers to how things seem at a given moment, whereas passage is a higher order comparison of how things seem at different moments. The point of that distinction emerges in connection with the question whether we perceive motion. No assumptions are made that this list is either exhaustive or exclusive.

92 in darkness. They are usually introduced with vague and poetic language. Openness  
93 rarely even warrants mention as something to which a sensible content can be  
94 assigned. Together, these aspects of temporal experience capture the Heraclitian  
95 vision of a universe in process, undergoing an absolute and irreversible process of  
96 *coming into Being*.

97 To many working in the foundations of physics, discussion of our experience of  
98 time is too imprecise and ill-defined to support real *research*. The most common  
99 reaction among those who are committed to physics as the source of ontological  
100 belief has been to dismiss the impression of passage, flow or openness as either  
101 nonsense or illusion: nonsense, because they are difficult to give non-metaphorical  
102 expression to; illusion, because there is nothing in physics that they would seem to  
103 describe.<sup>7</sup> But since experience is supposed to provide the evidence for our physical  
104 theories, physics can't ultimately avoid the need to connect itself to experience. The  
105 relationship between the flowing time of everyday sense and the static manifold of  
106 relativistic physics is one of the great, outstanding questions in our understanding of  
107 ourselves and our place in the universe.

108 In this paper, I outline a strategy for bridging the gap between the time of every-  
109 day experience and the time of physics which treats the Block Universe as a non-  
110 perspectival view of History and shows how to recover the everyday experience of  
111 time as a view of History through the eyes of the embedded, embodied participant  
112 in it. I also address questions about whether features of our temporal experience like  
113 passage and flow are properly thought of as illusory, the temptation to reify these  
114 features in the absolute fabric of the universe, and, finally, whether this strategy  
115 takes passage seriously.

## 116 6.1 Reconstructing Experience

117 We begin with some terminology. I use 'History' (capitalized) here to mean world-  
118 history, i.e., all of what happens everywhere from the beginning of time to the end.  
119 I use 'the view of History *sub specie aeternitatis*' to mean a representation of  
120 History whose content is invariant under transformations between temporal per-  
121 spectives. The phrase 'sub specie aeternitatis' comes from Spinoza and it had a  
122 meaning for him that I don't want to take on board. The view *sub specie aeternitatis*,  
123 as it is intended here, is simply a representation of History that is not relativized to  
124 a temporal frame of reference. It captures only those intrinsic relations among  
125 events, independently of their relation to viewers, or anything else. The view *sub*  
126 *specie aeternitatis* is the temporal analogue of the view from nowhere. So conceived,  
127 the notion of the view *sub specie aeternitatis* is formally well-defined, though it is  
128 hard to find locutions that don't suggest perceptual metaphors that are somewhat

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<sup>7</sup>Or worse, nonsensical. It is just as hard to characterize what these are supposed to mean in non-metaphorical terms, as it is to reconcile it with the relativistic image of time. There are some dissenters: Ellis (2008), John Norton (2010), and Smolin (2014).

inappropriate. So, for example, we speak of the ‘*view sub specie aeternitatis*’ or the ‘temporally transcendent *perspective*’. I’ll continue to use these locutions, but I want to disavow the literal interpretation as point from which a space is *viewed*. The formal apparatus for talking about the relationship between frame-dependent and frame-independent representations is very well-developed, and the analogy with space is helpful to keep in mind.<sup>8</sup> When we talk about a perspectival representation of space, we give that content as representation of space that is implicitly relativized to a frame of reference defined by the observer’s location and orientation in space. There is a logical transformation that takes us from a non-perspectival representation to a perspectival one and back.<sup>9</sup> In what follows, I give a similarly explicit characterization of ‘the participant’s perspective on History’ and show how to obtain a *transformation* that takes a static image of a four-dimensional manifold into an evolving image of a universe in the process of Becoming.

Here is how the transformation is defined. We start with an account of how History looks from the perspective of a particular moment. Formally, the view of time from a particular moment is like the view of space from a particular location. Just as the view from here is a representation of a three dimensional manifold relativized to a reference frame defined by three points (one for each spatial dimension) in the space, the view from now is a representation of a linear order implicitly relativized to a point in it. The events of History are divided into three sets (past, present, and future) depending on their relationship to now. Different events are past relative to different moments in History, just as different points are nearby relative to different locations in space. The content of a representation of the world from a particular moment is like a snapshot of History taken from the here and now. The view of History over some interval—a day, a year, a life—is obtained by stringing together the snapshots from the moments that comprise the interval, in the order defined by their appearance in the interval. So, for instance, we get the view of a football game through the eyes of the wide receiver by stringing together the snapshots that represent his momentary perspectives from the beginning of the game to the end.

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<sup>8</sup>There are many good discussions of reference frames in physics. For a nice philosophical discussion of the connection between invariance and objectivity, see Nozick (2001). The *locus classicus* of the philosophical discussion of the ‘unembedded’ or non-perspectival view of History see Nagel (1989) and Williams’s (1976) remarks on the Absolute Conception of Reality. See also Ismael (2007) where the formal apparatus for talking about invariant content and the transition from embedded representation, whose content tends to be context-dependent, to forms of representation whose content is invariant under transformations between contexts.

<sup>9</sup>And in the spatial case, there is an object—the observer’s body—that moves through the landscape as the frame changes. In the temporal case, whatever we mean by a temporal frame of reference, there is no object that moves through time as that frame changes. But even in the spatial case, the frame of reference is a relation between the contents of two kinds of representations: a visual representation in which space is represented in a manner that is relativized to a frame—either egocentric or allocentric, as the case may be. The viewer’s map of her body and its location in space plays the role of the ‘you are here’ dot allowing her to coordinate visual information with spatial information (Klatzky 1998).

159 It is not trivial to get the content of these snapshots right. The natural thought is  
 160 that the view of History from a particular moment is a combination of what the  
 161 viewer is seeing at that moment and the contents of his memory, and that the percep-  
 162 tual part ('what the viewer is *seeing*') is a representation of the occurrent state of the  
 163 environment. If that were right, perceptual representations themselves would repre-  
 164 sent instantaneous states of the world. Representations of motion and change, or  
 165 temporal relations like before and after, or duration, would occur only in memory,  
 166 where we construct representations that span longer intervals of history. And they  
 167 would be inferred from comparisons of perceptually apprehended positions at dif-  
 168 ferent moments.

169 Many people nowadays reject this simple view of perception. Two primary argu-  
 170 ments are given. One is the phenomenological evidence that motion is perceived  
 171 directly, rather than inferred. What you see when watch a long pass tracing an arc  
 172 across the sky is not a sequence of positions—the ball there, then the ball there, then  
 173 the ball there—but a ball moving in a certain direction at a certain speed. Direction  
 174 and speed belong not to points, but *intervals* of time.<sup>10</sup> The fact that you don't *infer*  
 175 the direction and speed from a sequence of perceived positions, but *see* the direction  
 176 and speed means that the *content* of even an *instantaneous* perceptual state spans a  
 177 finite region of both space and time. The second argument is that perceptual illu-  
 178 sions that have been well-documented in the lab bear out the idea that the brain is  
 179 representing what happens over a temporal interval. Some experiments suggest that  
 180 the interval extends (surprisingly) into the future.<sup>11</sup> If this is correct, then perception  
 181 delivers not a sequence of static snapshots, but representations of movement and  
 182 change. The intervals represented in perception, however, are very small. Estimates  
 183 range from 25 to 240 msec. Much longer intervals are represented in memory and  
 184 this is where, uncontroversially, most of the complex temporal content is  
 185 contained.

186 Memory comes in numerous forms. Episodic memories take the form of recol-  
 187 lected images, sights, sounds and smells. Autobiographical memory is devoted to  
 188 the time-consuming work of constructing, interpreting, and condensing life experi-  
 189 ences to produce a narrative account of a personal past.<sup>12</sup>

190 Perception and memory are both selective and reconstructive. There has been a  
 191 lot of fascinating and somewhat surprising research in the last decade or two about  
 192 the scope of the reconstructive nature of perception. It turns out that the brain does  
 193 more than simply integrate information over a temporal interval. Instead, what you  
 194 see is the prepared product of complex processing that involves filling in and pro-  
 195 jecting forward temporal inference. Between the moment the light hits your retina

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<sup>10</sup>This is the proper way to understand William James' specious present. One has to be careful not to mistake the claim that the temporal content of perceptual representations spans a finite interval for a claim about how temporally wide the state itself is. This would be like saying that because a perceptual state represents an expanse of space, it must occupy that expanse. See Grush (2009).

<sup>11</sup>See Grush (2007) and Eagleman (2011).

<sup>12</sup>There is also semantic memory, muscle memory, and any number of others, which are less relevant for our purposes. See Sutton (2012) for a taste of the breadth of memory processing.

and your conscious awareness of the scene in front of you, there is a good deal of computation going on in your brain. This is a rich area of research that is turning up fascinating results.<sup>13</sup> With regard to memory, selection and reconstruction are less surprising, and there is a long history of research that confirms that there is a good deal of processing, and some confabulation, particularly in autobiographical memory.<sup>14</sup>

So far, we have been talking of our representations of the past. But we are forward-looking creatures and we represent the future as well as the past. Our representations of the future have a very different epistemic character from our representations of the past. There are two asymmetries in our relationship to past and future events. There is the epistemic asymmetry: we don't remember the future, so our expectations for the future are guesses at best, gleaned from information contained in perception and memory and eventually overridden by future experience. And there is the practical asymmetry:<sup>15</sup> since our beliefs about (some of) what happens in the future depend on what we decide, those beliefs about the future can't be settled until our decisions are settled. From the perspective of the decision-maker, making up her mind about what to do is also making up her mind about how the future will be.<sup>16</sup> When we represent History from the perspective of a particular moment, we see a fixed History, represented in a patchy way in memory, but beyond volitional control. When the decision-maker looks into the future, she sees a range of open possibilities whose resolution into fact hinges on decision.<sup>17</sup>

The asymmetries, as I have described them, are asymmetries in our epistemic and practical relations to the events being represented at different points in our lives. We can (and should) ask about the physical basis of these asymmetries, but for now we need to observe only that these practical and epistemic asymmetries are phenomenologically fundamental and structure our cognitive representations of the world. They form the practical and epistemic lenses through which we view the world. If we look at how our representations of time change as we run through the repeated cycle in which we preconceive our histories, plan, act, and feed the

<sup>13</sup>Dennett reported some of this work in *Consciousness Explained*. More recent work by Grush, Clark and Eagleman confirms and extends it.

<sup>14</sup>Gazzaniga (1998), and others. The word 'confabulation' suggests that memory is malfunctioning. That misses the point that autobiographical memory is not just a record of the past, but how we process information about the past for practical use. Telling the story of your past is a way of making up your mind about its significance. See also Schechtman (1996).

<sup>15</sup>We represent the future both in a passive epistemic mode (as when we are wondering, for example whether it will rain tomorrow), and in a deliberative mode (as when we are envisioning possible futures for ourselves and making decisions about how to act). These correspond to the two uses of "I think I am going to" in Anscombe's (1957) famous contrast between "I think I am going to be sick" and "I think I am going to take a walk".

<sup>16</sup>See Ismael (2011), also Velleman (1989), Joyce (2002), and Price (1992). In Ismael (2011) 'making up one's mind' is analyzed as a kind of mental performance. This imaginative picture is regimented formally in decision theory, in which the future is represented by a set of act-dependent possibilities, which are resolved into a singular outcome by the decision process itself.

<sup>17</sup>For the best, recent, book-length discussion of the nature of these asymmetries and their physical basis, see Albert (2000).

225 observed results of our actions into the next cycle of planning, we will find that the  
 226 same events are represented from multiple perspectives: first in anticipation, later *in*  
 227 *praesentia*, and finally in retrospect. If we look lengthwise over the course of a  
 228 History, we see the changing perspective. And since memory is also keeping records  
 229 of how the History looked through our eyes from one moment to the next, that  
 230 structure is reproduced in every moment—like a set of nested snapshots of how  
 231 History looked from the various temporal perspectives that make up our lives. The  
 232 result is that the temporal content of an instantaneous cross-section of a normal  
 233 human life is the accreted product of a more or less continuous cycle of reflective  
 234 representation and re-representation in which perspectives are layered on top of one  
 235 another. It is important to understand that we don't just represent the world. We  
 236 represent our *own representations*,<sup>18</sup> capturing our epistemic and practical relations  
 237 to what we represent, comparing our expectations with what actually happens, and  
 238 opening up the space for complex attitudes like surprise, regret, disappointment, or  
 239 relief, and making the change in our perspective, itself, something that is repre-  
 240 sented in thought, often as an object of poignant awareness. Throughout all of this,  
 241 History itself is represented as the fixed object of representation. It is part of the  
 242 content of our representation that the event anticipated is the *same* as the one expe-  
 243 rienced, and later remembered, and that what changes is our temporal perspective of  
 244 the event; just as it is part of the content of our representation of a table as we walk  
 245 around it that it is one and the same table that is seen now from this angle and now  
 246 from that.<sup>19</sup> When people reflect on the passing of time, often they are calling atten-  
 247 tion to this change in perspective by looking back on events to which they earlier  
 248 looked forward.

249 The upshot of all of this is that perception and memory working together produce  
 250 an intricate structure of linked representations of the same moments in time, viewed  
 251 from different perspectives over the course of a life. The human mind seems to be  
 252 the only one whose representational states have this much explicit temporal content.  
 253 Other creatures see movement and change, and other creatures seem to have map-  
 254 like representations of *space*, but it is not clear whether there are other animals  
 255 whose representational states have an explicitly articulated temporal dimension, i.e.  
 256 an internal map-like dimension in which they store information about events when  
 257 they are not happening. We may be the only ones, that is to say, who have a concep-  
 258 tion of History as it appears *sub specie aeternitatis*.<sup>20</sup> Just as we have a concept of  
 259 space itself, independent of our relationship to it, we have a concept of History  
 260 itself, independent of our relationship to it. History itself, or History viewed *sub*  
 261 *specie aeternitatis*, is just what happens, a four-dimensional pattern of events. We  
 262 can describe it back to front or front to back. It is not dynamic. It has no direction.

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<sup>18</sup>The difference here is subtle but important. Think of the difference between a news report that simply describes the events of a battle, and one that reports on its reporting of the events.

<sup>19</sup>It needn't have been that way. We might have simply been aware of patterns of light and color. That wouldn't have been awareness of the world *as such*. There is little question that our spatial and temporal concepts have this much articulation.

<sup>20</sup>On the idea of an explicitly articulated temporal dimension, see Ismael (2007).



It is only when we look at how the world is represented in the representational states of a participant in it that we find the interpretations for flow, passage, and openness. The phenomenology of flow is a product of the way that the brain processes sensory information. The research on temporal illusions seems to confirm what we all know from experience, viz., that even the most rudimentary perceptual experience is an experience of change or motion. The sense of passage arises from the aforementioned poignant awareness of our changing perspective on history. Openness is a feature of the way that the future looks to the decision-making agent. From the perspective of such an agent, the decision process itself resolves a collection of open possibilities into singular fact.

The degree to which this strategy for reconciling human time and physical time is successful will depend on the degree to which it can faithfully recover the real, lived experience of the participant in History, and so these analyses of flow and passage and particularly openness have to be developed with some care. That is something I have tried to do in other places, but here I want to focus on the logic of the proposed relationship between the view *sub specie aeternitatis* and the view through the eyes of the participant. The claim is that in the view of History through the eyes of the embedded, embodied participant, events are ordered by their practical and epistemic relations to the viewer at different points in her life so that when they are strung together in a temporal sequence, they produce a changing image of a world with a fixed past and open future, in the process of coming into Being. Passage, flow, and openness arise as artifacts of changes in perspective, relative to the fixed backdrop of History. In the view *sub specie aeternitatis*, by contrast, those same events are represented in a way that is invariant under transformations between temporal perspectives. This doesn't mean that the practical and epistemic asymmetries disappear, but their relational character is now made explicit in precisely the same way that when we move from a perspectival representation of space to a map-like representation, relations like 'nearby' are explicitly relativized to spatial perspectives. And we can transform between the view *sub specie aeternitatis* and the view through the eyes of the participant in History in the way we can transform between egocentric and map-like representations of space.<sup>21</sup>

## 6.2 Closing the Circle: From Thinking inside Time to Thinking outside Time and Back<sup>22</sup>

There is a lesson in all of this that bears on my opening remarks pertaining to the relationship between the manifest image and the scientific image of the world, which is to highlight the broadly logical suggestion that the reason that time has

<sup>21</sup> And from a relativistic perspective, of course, space and time are united in the Block Universe and perspective is conceived as the here-now of located experience.

<sup>22</sup> The phrases 'thinking in time' and 'thinking out of time' are introduced by Smolin (2013).

299 seemed so hard to accommodate is that there is a crucial component in the relation-  
300 ship between the manifest and scientific image that has been left out.

301 Physicists have focused a good deal on transforming a fine-grained macroscopic  
302 model into a coarse-grained image, but the task of transforming a view of time sub  
303 specie aeternitatis into a view through the eyes of the embedded, embodied *partici-*  
304 *pant* in history (in ways that explicitly recognize how events are ordered in her  
305 experience and by her practical and epistemic relations to them) has remained out  
306 of focus. I tend to think of these in somewhat picturesque terms as two separate  
307 dimensions that have to be bridged in relating physics to phenomenology.

308 The reason that physics has done a decent job accommodating asymmetry, but  
309 not such a good job with flow, passage, and openness, I would suggest, is that asym-  
310 metry is an artifact of the shift from a microscopic to a macroscopic perspective,  
311 whereas flow, passage, and openness arise in the transformations wrought in that  
312 horizontal dimension. Adding the horizontal dimension allows us to close the circle,  
313 bringing experience and ontology back together as part of a single, unified vision of  
314 the universe in which experience furnishes information about ontology and ontol-  
315 ogy includes experience.<sup>23</sup>

316 Those familiar with Hartle's paper "The Physics of Now" will recognize from his  
317 discussion the seeds of this strategy for reconciling the relativistic image of time  
318 with our temporal experience. In that paper, he showed how to find an interpretation  
319 of the distinction between past, present and future in the representational states of a  
320 system whose practical and epistemic perspective mirrors our own (i.e., in a robot  
321 with a memory and sensors that moves around the world gathering information and  
322 using it to guide behavior). One of the reasons that Hartle's IGUS made an impor-  
323 tant impact in the physics literature on time, is that it is an effective tool for bringing  
324 issues about experience back into the fold of physics without getting caught up in  
325 the philosophical tangles associated with mental phenomena. The IGUS provides  
326 something purely objective that can serve as a kind of bridge between the dialectical  
327 worlds of figures as different as Einstein and Bergson.<sup>24</sup> When Bergson talks about  
328 human experience, he will want to talk about something identified by the role it  
329 plays in human life that Einstein will want to dismiss as outside the purview of  
330 physics. But if we can identify representational states inside an information-  
331 gathering and -utilizing device like a robot, which at least have the same functional  
332 role as the progression of states that constitute our conscious mental lives, then we  
333 can *locate* something that even Einstein will have to recognize falls within the pur-  
334 view of physics, and we will have found some common ground. Now we have a  
335 two-part story. The first part of that story is recognizable as physics. It describes the  
336 emergence of the thermodynamic gradient and the dynamical asymmetries that  
337 characterize the observed world. The second part of that story is less recognizably  
338 *physics*, though it is of a piece with the physical story. It is the story of how the  
339 thermodynamic gradient paved the way for the emergence of information-gathering  
340 and -utilizing systems and how the world is represented in the internal states of

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<sup>23</sup>Closing the circle, in Shimony (1993).

<sup>24</sup>See Canales (Chap. 4, this volume).

those systems. Asymmetry arises at the first stage. Passage, flow, and openness arise at the second stage.

Just as there is no need (or warrant) for reifying at the fundamental level, those features of the observed world that are generated at the first stage, there is no need (or warrant) for reifying, in the absolute structure of time, features of experience that are generated in the second stage. At the fundamental level, we have the static four-dimensional manifold with only those temporal asymmetries that are dictated by our microlaws. At the macroscopic level we have the thermodynamic gradient. At the level of human psychology, we have the flowing, directed time of everyday sense.

### 6.3 Relative Versus Absolute Becoming

This way of reconciling the Parmenidian and Herclitian visions of time also provides a formal resolution to the logical puzzle presented by McTaggart's argument, i.e., the puzzle of how to integrate the A-series with the B-series.<sup>25</sup> The B-series is the set of moments of history ordered by relations of temporal precedence. The A-series is the set of moments divided into past, present and future, hence ordered by their relation to the present moment. McTaggart argued that the two series' could not be integrated, and hence that the very same moments that had fixed locations in the B-series could not consistently be regarded as ordered by their relations to the present moment. The conclusion of his argument was that either (i) A-series properties are implicitly relativized to B-series locations, in which case the B-series is (really) all there is, or (ii) we get a contradiction. The strategy I have proposed comes down firmly on the side of 'The B-series is all there is, in the absolute, non-relational structure of time'. A-series properties are included implicitly as B-series properties relativized to a complex, evolving perspective.

Although the underlying logic is complex, the view just formalizes things that, I would argue, we all know. We know that we can willfully affect things that lie in our future, but not things that lie in our past. We know that we can remember things that lie in our past, but not our future. And we know that the practical and epistemic asymmetries that characterize the view of history from a particular moment are perspectival, in the sense that they are different at different moments in our lives. An event that is anticipated at one time is remembered at another. An event that is open (i.e., within practical reach) at one time is fixed (beyond practical reach) at another. These differences are not intrinsic to the events that constitute History, but differences in the relations that we bear to those events at (or from) particular moments in our lives. The way that we integrate information about History over time, moreover, makes it clear that we know the difference between structure that represents the intrinsic ordering among events, and structure that is relative to a spatial or temporal perspective. We know that the division into past and future is relative to a moment.

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<sup>25</sup>McTaggart (1908).

380 We know that the same event is future at one moment, present at another, and past  
 381 at others. When we integrate information about events across multiple perspectives,  
 382 we identify yesterday's tomorrow with tomorrow's yesterday and understand how  
 383 our relationship to the day has changed in the interim. When we update our beliefs,  
 384 we make it clear that we understand that what could have been avoided yesterday is  
 385 now beyond avoiding. In short, everything about the way that we manage our beliefs  
 386 about the world makes it clear that we understand that the division between past and  
 387 future, together with all of the practical and epistemic asymmetries that that division  
 388 imposes on our relations to events, is perspectival.

389 When History is represented *sub specie aeternitatis* we are forced to relativize  
 390 the perspectival structure to make it invariant under transformations between  
 391 momentary perspectives, and so we make explicit what we all know in the separa-  
 392 tion of perspectival structure from structure that is intrinsic to time. The practical  
 393 reason that we go in for representing time in a manner that is invariant under trans-  
 394 formations between temporal perspectives is that doing so supports planning. In  
 395 order to form a coordinated, temporally extended plan of action, one has to map out  
 396 the parts of the action and keep track of one's progress.<sup>26</sup> This form of representa-  
 397 tion, however, is not telling us anything that we don't already (at least implicitly)  
 398 know about the metaphysical status of features like past-ness, presentness, fixity  
 399 and openness.

400 It has been customary for those that accept Parmenidean metaphysics of time to  
 401 reject passage, flow, and openness as illusory, often citing Einstein's famous remark  
 402 about the distinction between past, present, and future being a stubbornly persistent  
 403 illusion.<sup>27</sup> The thought seems to be that if passage, flow and openness are mere arti-  
 404 facts of perspective, they aren't 'real' or objective.<sup>28</sup> I don't see that this talk of illu-  
 405 sion can withstand scrutiny. Perspectival structure is recovered in the view of time  
 406 *sub specie aeternitatis* as explicitly relational, on precise analogy with the spatial  
 407 case. No structure is lost. Passage, flow and openness remain as real as the differ-  
 408 ence between nearby and far away, the distinction between up and down. The lesson  
 409 is not that Parmenideans win and Heraclitians lose. It is that there is no genuine  
 410 conflict. The view *sub specie aeternitatis* includes the evolving view of time pre-

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<sup>26</sup> See Bratman (1987) on time, planning and agency.

<sup>27</sup> In other moods, Einstein took it quite seriously. Carnap reports that: "Once Einstein said that the problem of Now worried him seriously. He explained that the experience of the Now means something special for man, something essentially different from the past and the future, but that this important difference does not and cannot occur within physics. That this experience cannot be grasped by science seemed to him a matter for painful but inevitable resignation. I remarked that all that occurs objectively can be described in science; on the one hand the temporal sequence of events is described in physics; and on the other hand, the peculiarities of man's experiences with respect to time, including his different attitude towards past, present and future, can be described and (in principle) explained in psychology. But Einstein thought that these scientific descriptions cannot possibly satisfy our human needs; that there is something essential about the Now which is just outside the realm of science" (1963, p.37).

<sup>28</sup> Even with the good guys, people like Craig Callender (2010); Sean Carroll (2010), who agrees, in outline, about where an explanation of the experience of passage should come from, the vocabulary of illusion remained firmly in place.

sented in the experience of the participant in History as a view through the eyes of the participant in History, with the practical and epistemic lenses imposed by the physics of the environment and the terms of her embodiment. The view through the eyes of the participant includes the view *sub specie aeternitatis* as the invariant relation among the parts of time.<sup>29</sup>

On this view, there is no relevant logical or ontological difference between the status of the Heraclitian properties of flow, passage, and openness and perspectival spatial properties like the far away-ness of Neptune or the motion of the houses lining a street when viewed through the window of a moving train. When we move to a representation whose invariance class includes a parameter, *P*, structures that were absolute before the move get explicitly relativized to *P*-values. No structure gets demoted from ‘real’ to ‘unreal’. We simply have a representation of the structure that separates the absolute from the relational and makes the relational character of *P*-relational structures explicit. To think that accepting the Block Universe as an accurate representation of time as it appears *sub specie aeternitatis* means rejecting passage, or flow, or openness, as illusory is like thinking that accepting a map as a non-perspectival representation of space means that you are under an illusion that anything is nearby.<sup>30</sup> As we develop an increasingly absolute conception of the world, more and more of the structure at the forefront of our experience of the world is revealed to be perspectival. It’s difficult to say how ‘perspectival’ came to be associated with ‘unreal’,<sup>31</sup> but that association has been one of the most insidious and confusing aspects of the physical discussion of time. I have emphasized that perspectival structure of the kind that is being discussed here is perfectly real; it is just implicitly relativized to distinctions introduced by the agent’s perspective.

<sup>29</sup>Sometimes people speak as though the defenders of passage are just making the mistake that if they see a world line written down on a piece of paper, it doesn’t look like it is changing, so they reject the view that change is just having different properties at different times. Of course, that is a mistake. We can represent change by stringing representations of moments together in a temporal sequence, but we can also represent it by arranging representations of moments lengthwise along a page with the temporal parameter represented by the horizontal dimension along the page, or by writing down a mathematical function that represents evolution with respect to time. But to think that is the mistake that is always in play underestimates the problem. The problem is that we need to get flow and passage and openness into the content of experience without reifying them in the absolute fabric of the world.

<sup>30</sup>The logic of the relationship is a little complicated, because time is both what is being represented in the content and defining the frame from which it is represented, so we get the impression of the events of History being ordered and reordered by their relations to an object—the now-moving through time. For more on this see Chap. 10, Ismael (2007). The technical resolution is that the now is not an object, but the fixed point in a series of frame-dependent representations of time that has different values for different elements in the series.

<sup>31</sup>It may be an artifact of the tangled history of coordinate systems in physics. ‘Perspectival’ came to be associated with ‘coordinate-dependent’ which is used to identify aspects of mathematical representations of space-time that have no physical significance. There are many excellent accounts of that history. See especially Friedman (1983). Or perhaps it was because perspectival means implicitly relational, and hence neither absolute nor fundamental. But the ‘real’ is surely not coextensive with either the absolute or the fundamental.

435 There *is* an illusion if we treat perspectival structures as absolute, that is, if we  
 436 reify structures that belong properly to the perspective of the participant in History in  
 437 the absolute fabric of space and time. So, for example, if we treated the division into  
 438 past, present, and future, and the practical and epistemic asymmetries that go with  
 439 that division, as intrinsic features of events, we would be subject to an illusion. Who  
 440 makes this mistake? If the metaphysics of common sense are culled from everyday  
 441 practices of integrating temporal information over time, we can't convict common  
 442 sense of this mistake. It is, however, what happens when common sense begins to  
 443 philosophize, or when we take the little pictures that people carry around in their  
 444 heads as metaphysical commitments. It is likely true that the man on the street carries  
 445 around a picture in his head of a universe unfolding as he experiences it. But it  
 446 is also true that the way he integrates temporal information across perspectives  
 447 shows that he is *not* subject to that illusion. He uses calendars and time-lines unproblematically,  
 448 and probably doesn't spend much time worrying about how to fit the  
 449 two pictures together.

450 McTaggart's argument was intended to show that common sense has an incoherent  
 451 metaphysics of time. I think that what it actually shows is that common sense  
 452 doesn't have an articulate metaphysics of time, and so can be easily drawn into  
 453 contradictions. When the man on the Clapham omnibus is forced into metaphysical  
 454 commitments by an insistent questioner, or when the philosopher tries to form an  
 455 explicit response to McTaggart's argument, he gets tied up in knots. But the *pre-*  
 456 *philosophical* phase of temporal thought, it seems to me, is fine. McTaggart's argument  
 457 initiates a deeply confused philosophical phase, because the logical structure  
 458 of beliefs about time is quite complex. This progression from unreflective common  
 459 sense, through philosophical perplexity, to an articulate metaphysics is characteristic  
 460 of the sorts of problems that arise when common sense is put under philosophical  
 461 pressure.<sup>32</sup> It is a lovely illustration of the dual role of philosophy, leading first *into*,  
 462 and then (one hopes) *out of*, confusion.

## 463 6.4 “Taking Passage Seriously”

464 The relational view is often said to “not take passage seriously”. This charge is  
 465 made, for example, in a recent paper by Pooley. Here is the abstract::

466 Is the objective passage of time compatible with relativistic physics? There are two easy  
 467 routes to an affirmative answer: (1) provide a deflationary analysis of passage compatible  
 468 with the Block Universe or (2) argue that a privileged global present is compatible with  
 469 relativity. (1) Does not take passage seriously. (2) Does not take relativity seriously.<sup>33</sup>

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<sup>32</sup>I recognize, of course, that the line between carrying around a mental picture and elevating it to the status of a metaphysical view is a very fine one, and whether there really are any philosophical innocents is a real question. Whether my pre-philosophical man—my man on the Clapham omnibus—is a mythic figure or a real one doesn't matter for our purposes here, but I think that philosophers are overly inclined to think that everyone is a metaphysician. I think that many of the people I know best never asked the question “What is time?” in a form that demands a metaphysical answer. And I think the pre-philosophical phase is a fine one to remain in.

<sup>33</sup>Pooley (2013).

If taking passage seriously is a matter of insisting that passage is a real feature of our temporal experience, and demanding that physics be able to account for it, then the view I have argued for takes passage very seriously indeed, but it does not satisfy Pooley's definition of taking passage seriously. Part of the reason that one might deny that the view takes passage seriously comes from the idea that on a relativized view passage turns out to be 'illusory'. I have said why I think it is mistaken. Certainly it turns out to be perspectival, but if there is one lesson to be emphasized, it is that perspectival structure is not always 'illusory'. It is an important part of the relationalist view that we do not have to reify the relational in order to regard it as real. Nor do we need to reify it to regard it as worthy of a distinguished role in human life. It makes perfect sense that our cognitive and practical lives should be organized around distinctions that have a merely relational significance. We care more about what is nearby than what is far away, not because what is nearby is intrinsically ontologically special, but because it is *nearby*. We care more about our own children than other people's children, not (or not just) because they are more intrinsically special than other people's children, but because they are *ours*. Indeed, I think that everything that we care about is at the interface between what (sub specie aeternitatis) is the case and *how* what (sub specie aeternitatis) is the case relates to the here and now, to ourselves, and to our place in History. To be human is both to have an eye on eternity and feet in the here and now. By 'taking passage seriously', Pooley means not simply reconstructing passage as a feature in the experience of embedded agents, but underwriting a view according to which the universe itself is undergoing a process of coming into Being. I'll designate taking passage seriously in this sense, taking passage SERIOUSLY. Relationalists generally register puzzlement about what the idea is. For the relationalist, the Block Universe simply formalizes the recognition that the distinction between past, present and future (and all of the asymmetries that attach to that distinction), is relative to a moment in time. There is a good deal of talking past one another in the literature, with relationalists reconstructing all forms of passage in relational terms and opponents denying that this is what they mean.

Although the Block Universe is by far the dominant picture that one finds in physics textbooks, views that purport to incorporate non-relational forms of passage have recently made it into literature in the foundations of physics, conspicuously in the view of Smolin. The issue for Smolin focuses on the status of a global present, and to see what he has in mind, we need to look at the transition from Newtonian to Relativistic physics. In Newtonian physics, the notion of the state of the world at a time is well-defined and absolute. We can speak in a non-perspectival way of the state of the world at one time and represent the History of the universe as a sequence of states, one followed by the next. In this picture, time is treated as an external parameter in which the history of the world unfolds. The division between space and time is objective in the sense that it is not simply relativized to a point in a psychological history, but the history of the universe itself is described as a sequence of historical stages. In Special Relativity (STR), there is no longer the separation of space and time that allowed us to treat time as an external parameter. Spatiotemporal intervals are absolute; but spatial and temporal intervals are not. The distinction between temporal and spatial structure is not drawn globally, but locally, by the

516 light-cone structure at each point in space-time. Temporal order and duration are  
517 defined along a time-like curve. For any inertial trajectory there is a method for  
518 extending these local notions off the curve to a global notion of time, but if we com-  
519 pare the global notions, we will find that the global notions associated with different  
520 inertial trajectories disagree on which events are happening at a given moment. So  
521 judgments about which events are happening at a given moment are perspectival in  
522 STR but not in Newtonian physics. This is put by saying that there is no absolute  
523 notion of simultaneity in Minkowski space-time, or that there is no globally defined  
524 notion of the present state of the world. The story is a little more complicated in the  
525 General Theory of Relativity. There are no global inertial frames in a generic  
526 general-relativistic space-time. But in a neighborhood of any space-time point there  
527 is a continuous time-like curve in whose neighborhood one can define what is called  
528 a normal frame, which specifies a privileged family of instantaneous three-  
529 dimensional spaces and says what events in different instantaneous spaces occur at  
530 the same enduring place. The family, however, may not be defined globally. So  
531 while there is a well-defined frame in the neighborhood of every point in which we  
532 can talk about the state of the world, the state of the world at a time is still perspec-  
533 tival. The upshot is that, while the division between past, present and future was  
534 perspectival in Newtonian physics, in the sense that it was relativized to a moment  
535 in time, it is perspectival in a new and stronger way in relativistic theories. In rela-  
536 tivistic theories, the distinction between past, present, and future is relativized to a  
537 point along a time-like curve. Why does this matter? As long as there was a globally  
538 defined present, it was possible to invest the distinction between past, present and  
539 future with ontological significance, i.e. to think that it marks a distinction between  
540 what is real and what is not. In STR the manifold does not have enough invariant  
541 structure to support the ontological weight of that distinction.

542 The reconstruction of temporal experience that I have proposed separates the  
543 question of temporal passage—understood as something of which we are immedi-  
544 ately aware in experience—from the question of whether there is a globally defined  
545 present. It treats this last as a question for physics, to be settled by considerations of  
546 a kind that are far removed from everyday experience. On this view, we have an  
547 internal time, defined for the psychological history of embedded observers by the  
548 flowing, passing character of everyday experience. Communication among observ-  
549 ers (and the creation of time-keeping technologies like clocks and watches) will  
550 stabilize an intersubjective notion of ‘what time it is’ well enough for practical  
551 purposes, but leaves questions about the absolute structure of space and time to  
552 physics. It takes passage seriously in that it insists that, in order for our physics to  
553 provide an intelligible picture of ourselves and our place in nature, we need it to  
554 support real, lived everyday experience. But it denies that physics has to confirm  
555 folk ontology. By showing how to take passage seriously without taking passage  
556 SERIOUSLY, it shifts the burden of argument. Physicists like Smolin do take up  
557 that burden, marshaling considerations drawn from physics in support of the  
558 existence of a global present. But at this stage, the question is straightforwardly a  
559 question of physics. It has nothing directly to do with temporal experience.<sup>34</sup>

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<sup>34</sup>Nor does it seem to have anything to do with the Block Universe. It is not, for example, that a Block Universe is incompatible with the existence of a global present. The Block Universe is just



## 6.5 Concluding

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I have defended the Block Universe as an image of History as it appears sub specie aeternitatis and described a strategy for recovering the everyday experience of time as a view of time through the eyes of the embedded, embodied participant in History. I addressed the common misconception that perspectival structure is illusory and denied that a view that treats passage as perspectival fails to take it seriously. There remain many open questions about time in physics. There are questions about, for example, whether there is a globally privileged present<sup>35</sup> or a fundamental global form of ‘becoming’, or whether space-time is itself emergent from a non-spatiotemporal structure.<sup>36</sup> But the methods for answering these questions have nothing directly to do with reflecting on the character of our temporal experience. They are questions about whether these elements of structure are implicated in the movements of objects, i.e., whether there are law-governed differences in behavior explained by differential relations to those structures.

## Works Cited

574

- Albert, D.Z. 2000. *Time and chance*. New York: Harvard University Press. 575
- Andersen, H.K., and R. Grush. 2009. A brief history of time-consciousness: Historical precursors to James and Husserl. *Journal of the History of Philosophy* 47(2): 277–307. 576
- Anscombe, G.E.M. 1957. *Intention*. Cambridge, MA: Harvard University Press. 578
- Bratman, M. 1987. *Intention, plans, and practical reason*. Cambridge, MA: Harvard University Press. 579
- Callender, C. 2010. Is time an illusion? *Scientific American* 302(6): 58–65. 581
- Callender, C., and C. Wüthrich. 2014, 1 March. What becomes of a causal set. (Preprint draft). Retrieved from [http://philosophyfaculty.ucsd.edu/faculty/wuthrich/pub/CallenderWuthrich2014Causets\\_AprilWeb.pdf](http://philosophyfaculty.ucsd.edu/faculty/wuthrich/pub/CallenderWuthrich2014Causets_AprilWeb.pdf) 582
- Carnap, R. 1963. *The philosophy of Rudolf Carnap*, ed. P.A. Schilpp. New York: Cambridge University Press. 585
- Carroll, S. 2010. *From eternity to here: The quest for the ultimate theory of time*. New York: Dutton/Penguin Group. 587
- Eagleman, D.M. 2011. *Incognito*. New York: Pantheon Books. 589
- Eagleman, D.M., and J. Downar. 2011. *Cognitive neuroscience: A principles-based approach*. New York: Oxford University Press. 591
- Ellis, G.F. 2008. *On the flow of time* (No. arXiv: 0812.0240 [gr-qc]). 592
- Friedman, M. 1983. *Foundations of space-time theories*. Princeton: Princeton University Press. 593

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a generic framework that can support any absolute structure that can be defined on a four-dimensional manifold. Smolin associates the Block Universe with the reality of the future and is concerned to deny that the future is real. But again, here, one feels that there is some talking past one another. Surely events that are future now will be present later, and so questions of what is real have to be relativized along with the distinction between past and future, and the Block Universe is entirely compatible with that.

<sup>35</sup> See Maudlin (2007).

<sup>36</sup> Huggett and Wüthrich (2013).

- 594 Gazzaniga, M.S. 1998. *The mind's past*. Berkeley: University of California Press.
- 595 Grush, R. 2007. Time and experience. In *The philosophy of time*, ed. T. Müller. Klosterman:  
596 Frankfurt.
- 597 Grush, R. 2009. The temporal content of perceptual experience. In *The Routledge companion to*  
598 *philosophy of psychology*, ed. J. Symons and Calvo Paco. New York: Routledge.
- 599 Huggett, N., and C. Wuthrich. 2013. The emergence of spacetime in quantum theories of gravity.  
600 *Studies in History and Philosophy of Modern Physics* 44(3): 273–275.
- 601 Hunemann, P. forthcoming. Decision and the open future. In *The future of the philosophy of time*,  
602 ed. Adrian Bardon. New York: Routledge.
- 603 Ismael, J. 2007. *The situated self*. New York: Oxford University Press.
- 604 Ismael, J. 2010. Temporal experience. In *The oxford handbook of philosophy of time*, ed.  
605 C. Callendar. New York: Oxford University Press.
- 606 Ismael, J. 2011. Decision and the open future. In *The future of the philosophy of time*, ed. Bardon  
607 Adrian. New York: Routledge.
- 608 Ismael, J. forthcoming. Passage, flow and the logic of temporal perspectives. In *Cosmological and*  
609 *psychological time, The Nature of Time, The Time of Nature*, eds. C. Bouton and P. Hunemann.  
610 Chicago: University of Chicago Press.
- 611 Joyce, J.M. 2002. Levi on causal decision theory and the possibility of predicting one's own  
612 actions. *Philosophical Studies* 110(1): 69–102.
- 613 Klatzky, R.L. 1998. Allocentric and egocentric spatial representations: Definitions, distinctions,  
614 and interconnections. *Spatial cognition, January*, 1–17. Berlin: Springer.
- 615 Maudlin, T. 2007. *The metaphysics within physics*. New York: Oxford University Press.
- 616 McDaniel, K. 2013. John M.E. McTaggart, In *The Stanford encyclopedia of philosophy* (Winter  
617 2013 Edition), ed. E.N. Zalta. <http://plato.stanford.edu/archives/win2013/entries/mctaggart/>
- 618 McTaggart, J.E. 1908. The unreality of time. *Mind* 68(17): 457–474.
- 619 Nagel, T. 1989. *The view from nowhere*. New York: Oxford University Press.
- 620 Norton, J.D. 2010. Time really passes. *Humana Mente: Journal of Philosophical Studies* 13:  
621 23–24.
- 622 Nozick, R. 2001. *Invariances: The structure of the objective world*. Cambridge, MA: Harvard  
623 University Press.
- 624 Perry, J., and S. Blackburn. 1986. Thought without representation. *Proceedings of the Aristotelian*  
625 *society, supplementary volumes*, 137–166.
- 626 Pooley, O. 2013. Relativity, the open future, and the passage of time. *Proceedings of the Aristotelian*  
627 *Society* 113(3): 321–363.
- 628 Price, H. 1992. The direction of causation: Ramsey's ultimate contingency. In *PSA: Proceedings*  
629 *of the Biennial Meeting of the Philosophy of Science Association*, 253–267. Philosophy of  
630 Science Association.
- 631 Rea, M. (ed.). 1997. *Material constitution: A reader*. New York: Rowman & Littlefield Publishers.
- 632 Russell, B. 1927. *The analysis of matter*. New York: Harcourt, Brace & Company.
- 633 Schechtman, M. 1996. *The constitution of selves*. Ithaca: Cornell University Press.
- 634 Shimony, A. 1993. *The search for a naturalistic world view*, vol. 1. New York: Cambridge  
635 University Press.
- 636 Smolin, L. 2014. *Time reborn*. New York: Houghton Mifflin Harcourt Publishing Company.
- 637 Sutton, J. 2012. Memory. In *The Stanford encyclopedia of philosophy* (Winter 2012 Edition), ed.  
638 E.N. Zalta. <http://plato.stanford.edu/archives/win2012/entries/memory/>
- 639 Velleman, J.D. 1989. Epistemic freedom. *Pacific Philosophical Quarterly* 70(1): 73–97.
- 640 Williams, B. 1976. *Problems of the self: Philosophical papers 1956–1972*. New York: Cambridge  
641 University Press.