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# RELATIONAL PASSAGE OF TIME

Matias Slavov

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# Relational Passage of Time

This book defends a relational theory of the passage of time. The realist view of passage developed in this book differs from the robust, substantivalist position. According to relationism, passage is nothing over and above the succession of events, one thing coming after another. Causally related events are temporally arranged as they happen one after another along observers' worldlines. There is no unique global passage but a multiplicity of local passages of time. After setting out this positive argument for relationism, the author deals with five common objections to it: (a) triviality of deflationary passage, (b) a-directionality of passage, (c) the impossibility of experiencing passage, (d) fictionalism about passage, and (e) the incompatibility of passage with perduring objects.

*Relational Passage of Time* will appeal to scholars and advanced students working in philosophy of time, metaphysics, and philosophy of physics.

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# Abbreviations

I have abbreviated and I cite the following classics according to standard practices:

first *Critique* (KdRV)—*Critique of Pure Reason* by Immanuel Kant

*Discourse*—*Discours de la méthode* by René Descartes

*Principia*—*Principia. Mathematical Principles of Natural Philosophy* by Isaac Newton

*Treatise* (THN)—*A Treatise of Human Nature* by David Hume

# Preface

B-theorists and eternalists face a challenge: How to encompass passage in their ontology of time? Tense is treated indexically, so A-properties of past, present, and future are not objective features of the world. If this is correct, the future does not become the past via the present. Perhaps passage does not exist within the block universe. This implies that the world is not a process in which events constantly unfold; it just BE.

This concise book argues that the B-theory—as well as its close affiliate, the eternalist-relativistic account—does not predicate an utterly static view of reality. The realist view of passage as developed in this book, however, differs from the robust, substantivalist position. According to relationism, passage is nothing over and above the succession of events, of one thing coming after another. This is different from substantivalism, which treats passage as self-existing. Relationism propounds that we and our environment are rife with causally unidirectional change from earlier times to later times. There is no unique direction of time, but different observers agree on the order of timelike separated events and local directions. There is a plurality of B-series that contain the difference between being earlier than *x* and being later than *x* and of which we have veridical beliefs. There is no single passage of time but a multiplicity of passages along observers' worldlines. There are frame-invariant lapses of time as measured by proper time, although the rate of passage is relative to the specific path through spacetime. The passage of time is both relative and real.

# Acknowledgments

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I have reproduced material from two previous publications of mine. Chapter 3 includes material from a Finnish article, "Syyseuraus-suhteen ajallinen epäsymmetria," published in *Ajatus* 77 (2020), from pages 22–35, which I have translated myself. Chapter 5 includes material from a book review of Carlo Rovelli's *The Order of Time*, published open access in the *European Journal of Analytic Philosophy* 15 (2019), from page 74.

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# Introduction

The eternalist-relativistic account of the world abandons a universal present. Proponents of this view typically explain the nature of time by referring to the B-series. That series contains the temporal relations of earlier-than, simultaneous-with, and later-than. Additionally, if one rejects the substantivalist concept of time, according to which the flow of time stands on its own, one is led to consider a relationist ontology of time. That ontology contains the successive relations of before and after; temporal passing is nothing over and above those relations.

Provided that one groups together the above-mentioned concepts, as I shall do in this book, it seems difficult to admit any dynamic notions into one's ontology. If all temporal locations exist *simpliciter*, different times do not change. It is not a fact that the future becomes the 'now' and then drifts off into the past. If A-locations are not objective features of the world, the B-theorist should explicate what room, if any, passage has in one's ontology.

Treating the passage of time in a critical way is nothing new. Parmenides argued that temporal thought is contradictory. The passing of time requires that nothing, the future, becomes something, the now, and then this something, the now, becomes nothing, the past. The passing of time would be a contradiction, but there are no contradictions out there in the world, so in reality, there is no passage of time. McTaggart's (1908) famous article agreed with Parmenides in that tensed descriptions of the world are incoherent. An event should be either past, present, or future: it cannot be all three of them. If passage occurs, then distinct times should become one another. That would be illogical. In addition to the metaphysical and logical difficulties, passage is also at odds with relativistic physics. For time to pass, Gödel (1949: 558) famously noted, reality should be made of "an infinity of layers of 'now' which come into existence successively." In special relativity, spacetime can be foliated in various ways. Gödel thought that general relativity makes things even worse because it does not permit any foliation. So there is no succession of cosmic 'nows' which Gödel understood as being required for true

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passage. In contemporary debates, passage is commonly portrayed as illusory (drawing on psychological experiments), non-experienceable (the detector thought experiment), and non-existent (temporal fictionalism). If one emphasizes the symmetricity of laws of nature (time-reversal invariance) and the folk nature of our concept of causation (anti-causal philosophy of physics), passage lacks a definite direction.

In opposition to these widely held views, the present book makes a case for the reality of passage. I shall concentrate on deflationary/revisionist theories (including, for example, Dieks 2006; Dorato 2006b; Savitt 2009; Mozersky 2015; Fazekas 2016; Deng 2019; Leininger 2021[1]). These theories do not subscribe to A-theoretic metaphysics. They are still contrary to arguments that represent passage as irreal. Roughly and broadly, deflationism is committed to the following: the passage of time is the sequence of events along an observer's timelike worldline. This book explores how deflationism about passage fits with a generally relationist account of temporal existence.

Relationism is certainly not a novel creed. Leibniz used relational arguments in his correspondence with Newton's representative Clarke at the beginning of the 18th century. So did Mach in his *Science of Mechanics* in the late 19th century. Often, the 20th-century debates centered on spacetime substantivalism/relationism. Yet many of the arguments in these discussions are different from what I shall set forth in this book. At least they are formulated from a different point of view. Leibniz invoked the strongly rationalist principles of sufficient reason and identity of indiscernibles, which were to him connected to theological considerations.[2] This is different from the naturalist metaphysics as proposed here. Mach tried to eliminate trifling metaphysical concepts like absolute time.[3] This book is not anti-metaphysical; it belongs to studies in the metaphysics series. And instead of concentrating on the ontological status of spacetime,[4] I wish to apply relationism specifically and extensively to the debates concerning the ontology of passage.

The key point is to deny that there is such a thing as time itself. I affiliate substantivalism about time with absolute time. There is some confusion about these definitions in current debates. For example, James Read and Emily Qureshi-Hurst (2021: 8103) note that special relativity is usually thought to provide "evidence against absolute time—where 'absolute time' is defined as enshrining a universal present moment, objective temporal passage, and tensed facts." According to this cursory definition, 'absolute time' denotes a universal present moment that moves along as time passes. Tensed facts about the past and the future are somehow based on a well-defined present moment, which consists of all there is. I concur that absolute time is connected to all that. What I wish to add is that a defender of absolute time thinks there is such a thing as time itself. It exists substantially without anything else.[5] Relationist metaphysics rejects this. Instead of there being time itself, relationism maintains that physical events and notably their relations are fundamental for the existence of time. "There is nothing more to time at all," Sean Enda Power (2021: 10) states, clarifying the definition of relationism: "take those [objects, events and the like] away and there is no time. There are no possible worlds in which there is time but no objects, no changes, or no space."[6]

Substantivalism is a realist theory, whereas relationism might be idealist or realist. Under substantivalism and realist relationism, we have veridical beliefs about temporal reality. Time, including the passage of time, exists. Substantivalism and relationism disagree in which way passage exists. For the former, time itself changes from the future to the 'now' to the past. For the latter, timelike events come one after another. In defining passage, the former relies on changing temporal locations, whereas the latter on the succession of events.

## Methodological approach

This is a work of systematic philosophy of time that takes historical considerations seriously. To borrow from the analogy of Denis Robinson and Graham Priest, the history of philosophy is like a collection of chess openings. Good chess players have good knowledge of traditional openings. "Such is necessary," to quote from Priest (2020: 299–300),

> to take them to a point of the game where they can exercise novelty and real creativity. And if they do not know these, if they are playing an opponent who knows them properly, they are likely to have lost the game already by the time the opening phase is over. In a similar way, knowing the history of a philosophical issues is an important entry into understanding the subtleties of contemporary debates.

I am not familiar with Eastern traditions of philosophy, so the historical surveys in this book are limited to the so-called Western tradition. I engage in dialectic argumentation with significant historical sources as well as current contributions. The passage of time is a perennial issue in philosophy, comparable to other ancient problems such as free will. Asking whether eternalism is compatible with passage is like asking whether determinism is compatible with free will. Due to the nature of the problem, one may not expect knock-down arguments on either side. I will go on to devise a positive argument, consider objections, and answer them.

The approach is moderately naturalistic. Naturalism is not defined in any stringent way. The metaphysical views developed in the book should conform to the established physical theories, most notably to the ramifications of the theory of special relativity. There are good reasons to think that this theory is approximately true. There is a plethora of experiments and applications that rely on special relativity. It is integrated into various theories of modern physics. Special relativity corrected the preceding Maxwellian–Hertzian ether-based electrodynamics, and it is part of experimental high-energy physics, even the quantum field theory. It is also part of general relativity, which accounts for gravitational fields. Furthermore, special relativity is generally accepted by the international academic physics community. Accepting the truth of special relativity is as reasonable as accepting the truth of evolution, global warming, and the general efficacy of vaccines.

Special relativity is not the most fundamental theory as it is contained in the general theory of relativity. The general theory is likely an approximation of some more fundamental theory. The research programs concerning quantum gravity seek to unify general relativity and quantum mechanics. A naturalist metaphysics must say at least something about the implications of quantum gravity (McKenzie 2021). Quantum gravity indicates perhaps a timeless conception of the world (Rovelli 2009). It will be argued, along the lines of nonreductive physicalism, that the less fundamental features of reality, which could include the passage of time, are not any less real than the more fundamental features. Moreover, the atemporal conception does not threaten an eternalist understanding of the nature of time, which is the underlying temporal ontology as assumed in this book. If the world in some deep sense is tenseless, this reinforces the perspectival and indexical nature of tense.

Emphasizing the relevance of physical theories does not mean that ontological positions should only follow the scientific theory or that they are reducible to physics. The book engages in metaphysical theorizing on philosophical concepts such as causation, supervenience, fundamentality, mind-independence/dependence, and the like. On quite many occasions, the line between physics and metaphysics, or science and philosophy more broadly, is fuzzy. Willard van Orman Quine (1995: 256–7) famously saluted "the blurring of such boundaries. Naturalistic philosophy is continuous with natural science.... The boundary between naturalistic philosophy and the rest of science is just a vague matter of degree."[7] Physics and philosophy are different, but not dichotomously different. There is a spectrum. When assessing time's passage, it should be added that there are many other special sciences that are relevant, including, for example, psychology, linguistics, evolutionary biology, and cultural anthropology. Naturalistic philosophy is placed at the most abstract and general end of the spectrum; the aim is to figure out, in the broadest possible sense, what the nature of passage is.[8]

Noting the relevance of various fields raises the question of competence. I minored in physics at the University of Jyväskylä, where all my academic degrees are from. This means I have studied physics up to special relativity and a little bit of quantum mechanics. When it comes to general relativity, subtleties of high energy physics, and quantum gravity, I must rely on secondary sources heavily. The treatment of these theories is sketchy rather than quantitative. The same goes for other references to specific sciences. Instead of technical precision, discerning the ontological significance of the theories is the paramount task of this book.

## Other relevant books

The nature of passage is an intensely debated topic in the current philosophy of time. Hence, there are multiple books that treat the same issues as I do. It would be impossible to list all the relevant contributions. I can shortly explain how my project is different from some recent, or even forthcoming, approaches.

In *The Moving Spotlight* (2015), Ross P. Cameron claims that the correct metaphysics of time is an A-theoretic version of the moving spotlight. Cameron (2015: 2) encapsulates his position with two claims:

The first claim is:

> *Privileged Present*: There is a unique objectively privileged time: the time which is present. No description of reality can be correct and complete without specifying which time is present.

The second claim is:

> *Temporary Presentness*: What time is objectively privileged changes: the time that is objectively present either was or will not be present (or both), and some time that is not objectively present either was or will be (or both).

This book is at odds with the two claims. The 'now' is taken to be perspectivally real. It is neither unique nor privileged. Rather, there are as many present moments as there are frames of reference. Specifying which time is 'now' does not give a complete description of reality (somewhat in the same way as specifying which place is 'here' gives all but a complete description of reality). The 'now' denotes the observer's contingent location in spacetime. The present is understood as being inherently perspectival, not ontologically, or even experientially privileged. Passage is not explained in terms of changing tensed locations, like the moving present, but in terms of succession of events. Cameron (2015: 18–20) briefly mentions the two relativity theories. Yet he omits their ramifications. The most powerful criticism of presentism comes from a relativistic account of the world.[9] The presentist must accept the following to be true: the moment a nuclear reaction occurs in a star in the Andromeda galaxy, Michael Jackson is either dead or alive. Special relativity indicates there is no fact of the matter. Simultaneity varies across frames. There is no global 'now' that cuts throughout the whole universe (Balashov 2010:

2–3).[10] An event occurs 'now' relative to itself, but there is no privileged way to ascertain that this event is also 'now' relative to another spatially distant event. Whether we approach the issue by leaning on the conventionality or the relativity of simultaneity, the result is that no preferred way to "join the dots" is available (Brading 2015: 15).

Bradford Skow's (2015) *Objective Becoming* considers the feasibility of the spotlight theory within the block universe. He grants that the moving spotlight view is an apt account of the robust passage of time. This concession does not lead him to support the moving spotlight. Instead, he favors the block universe view over the changing 'now.' He rejects the view that time somehow itself flows or moves or that we move through time. There is no robust passage to be found from spacetime. Experience does not help us, either. This is where my position is different from Skow's: I think experience does give us truthful information about the passage of time, albeit not substantial (or in his terminology, robust) but relational passage. Moreover, my treatment of passage does not utilize the notion of a supertime in any way.

Samuele Iaquinto and Giuliano Torrengo set forth a novel theory about passage in their *Fragmenting Reality: On Fragmentalism, Time, and Modality* (forthcoming). According to fragmentalist metaphysics, reality is not ultimately a unitary place. The world is, among others, fragmented into collections of tensed facts. All fragments are internally coherent, but all reality is not. Obtainment in the present is not true *simpliciter* because of the variety of fragments that make up the world. Socrates is sitting or Socrates is standing are limited to specific fragments. Therefore, there are multiple fragments of reality that each has its own absolute (but not unique) tensed facts. By arguing for variation of A-properties through fragments, Iaquinto and Torrengo embrace a version of metaphysical pluralism. The flow of time is fragmented—within each fragment, different futures approach, become the present, and receded into the past—but no globally coherent unique flow exists. My view is different at least in two senses. First, I treat tenses as perspectivally real, not fragments of reality. I have argued for this position elsewhere (Slavov 2020a). Second, as I argue in this book, I do not think passage is a variation of A-properties but tenseless B-theoretic succession.

## The chapters in outline

Chapter 1 applies the general labels 'relationism' and 'substantivalism' to the theories of the passage of time. The main aim of this chapter, which is also the main positive argument of this book, is to develop an account of passage that is realist not in the substantial but in the relational sense. This is thus the longest chapter of the book, and the only one to apply subheadings apart from the Introduction. Relationism takes the plural nature of time very seriously, but in contrast to antirealist or idealist formulations, it is a form of realism. To contextualize the argument properly, classical antirealist and idealist arguments of passage are introduced in the beginning. Then the substantivalist thesis is laid out. After this, the relational argument is proposed.

Chapter 2 answers the obvious worry: Is the formulation of the deflationary theory changing the subject? The answer is no. Bringing the succession of events and passage together is not trivial, because succession is an instance of temporal extension. This is different from spatial extension. The latter is static, but the former dynamic. A succession of events is enough for our experience of passage—one does not need to invoke a special present or changing moments of time. The point is not only to lend credibility to the view that deflationary passage fits with our temporal phenomenology. Temporal relations, notably the successive before–after causal relations, hold objectively. There are frame-invariant lapses of time measured by the proper time along the timelike worldline: events succeed each other along the worldline. This is contrary to the subjective or idealist metaphysics of time, which heavily emphasize the human point of view. Relationism is a realist theory, which does not indicate the atemporality of physical reality.

Chapter 3 takes on the direction of time and argues that it is based on causation. The alignment of temporal direction and causation is articulated. The sequential theory of causation is defended against the simultaneous theory. There is a partial overlap of cause and effect, but the cause begins before its effect. It is argued that conservation laws do not exemplify causation. Although it might be that a fundamental physical description of the world lacks causation, paradigmatic instances of causation are temporally directed. It is pointed out that in many cases the distinction between physics and metaphysics is muddy. This weakens the anti-causal philosophy of physics stance. The chapter ends by considering a *reductio* argument: If causation and time in perception are not unidirectional, we are left with absurdities. It is explained how the one-directionality of time does not entail a unique direction of time.

Chapter 4 defends two theses: we correctly identify B-theoretic passage but are in error concerning our putative A-theoretic phenomenology. The detector and multidetector arguments, including their physicalist assumption, are approved. Yet this does not disprove the existence of passage altogether. Duration may be assimilated into passage. There are changes within durations that constitute our experience of time's passing. It is argued that instant perceptions do not give us the notion of change, but for us to have experience of change, memory and inferences are required. Our misdescription of A-theoretic passage phenomenology is due to the ubiquity of passage metaphors in language and the evolutionary history of our species. This broadly evolutionary view reinforces the perspectival nature of tense like the 'now' and so provides additional reasons against presentist metaphysics that relies on objective tense.

Chapter 5 engages with the thesis of temporal fictionalism. This thesis is motivated by fundamental, supposedly ultimate physical theories that portray the world as timeless, like quantum gravity. Temporal fictionalism suggests that our everyday temporal thinking is truth-app but false. The metaphysical theories consisting of A-series or B-series or C-series are all in error. The point made is that fictionalism does not adequately tackle mundane temporal thinking. Such thought requires causation, processing of information, and normative agentive considerations. These features are not reducible to the more fundamental physical descriptions. Moreover, even the hypothetical ultimate descriptions involve change. Temporal antirealism about that level should explicate how there can be change without time. The two are, after all, paradigmatically connected.

Chapter 6 takes up persistence. It starts with the observation that endurance in three-dimensional space does not have the intuitive advantage of being a more dynamic description compared to its four-dimensionalist alternative. The former depicts a unitary object within space. Whither time? In juxtaposing the two diagrams, it is the latter that seems intuitively more dynamic. Successive temporal parts are instances of change among different times and hence adequately capture the ontology of passage. The totality of what exists—the block universe—remains the same, but between earlier states of the local parts of the universe and its later states, there is change.

## Notes

1 There are important differences between these authors. Not all of them agree that their accounts of passage or becoming should be labeled deflationary. They are still not invoking A-metaphysics, which is usually thought to be necessary for the reality of passage.

2 McDonough (2019: Section 5) encapsulates the principles that Leibniz used to argue for his relational stance in his correspondence with Clarke.

3 Wolters (1992) goes through Mach's strategy to combat metaphysics.

4 For a thorough exposition of the substantivalist and relationist takes on spacetime, see Pooley (2013b).

5 In her comprehensive study of the history of absolute time, Emily Thomas (2018: 1) defines absolute time as follows: "time is 'absolute', something that is independent of human minds and material bodies." The purpose of this definition is to compare the 17th-century definition of time to traditional understandings, which treat time as a product of the mind, or the motion of heavenly bodies. This is how Bradley Dowden (2021: Section 5) puts the point:

> Classical substantival theories are also called *absolute theories*. The term *absolute* here means to exist without dependence on anything except perhaps God. Time cannot be influenced. A more modern sense of *absolute* is to be independent of reference frame.

6 For a thorough discussion of relationism, see Meyer (2013: Chapter 2).

7 James Jeans (1943: 17) made a similar statement to Quine's much earlier: "In whatever ways we define science and philosophy, their territories are

contiguous; wherever science leaves off—and in many places its boundary is ill-defined—there philosophy begins."

8 This is, of course, paraphrasing Sellars's (1962: 35) famous account: "The aim of philosophy, abstractly formulated, is to understand how things in the broadest possible sense of the term hang together in the broadest possible sense of the term."

9 There are many critiques of presentism that draw on relativity. Twenty-first-century critiques include, for example, Saunders (2002), Balashov and Janssen (2003), Peterson and Silberstein (2010), Wütrich (2010, 2012), Fazekas (2016), and Rovelli (2019). Moreover, Wütrich (2010) argues that cutting-edge research programs, like quantum gravity, do not lend support to presentism.

10 Some neo-Lorentzian interpretations of special relativity (e.g., as articulated by some essays in Craig and Smith 2008; Zimmerman 2008) retain the privileged present. The neo-Lorentzian view is, however, at outs with the consensus of the institutional physics community. These strategies revise science on theological and philosophical grounds. I concur with the following formulation of Baron (2018: 9): "For a Quinean naturalist, any such recommendation should be treated with suspicion." For a similar kind of critique, see Wütrich (2010: 264–5).

# Part I

# The positive argument

# 1 Relational, not substantial, passage

Relationism and substantivalism are typically used to describe dissimilar views concerning the ontology of space and time, or spacetime. The two creeds disagree on the ontological status of distance, duration, and motion.

According to a generic definition, substantivalism maintains that passage is self-existing. Time itself passes; passage is not derivative of anything else. The classical and paradigmatic argument for this view can be found in all editions of Isaac Newton's *Principia*, in the Scholium to the Definitions. In contemporary discussions, Tim Maudlin (2007) and John D. Norton (2010a) support substantivalism, albeit substantivalism updated to fit relativity. There are certainly other realists about passage, but what is distinctive about Maudlin's and Norton's contributions is the emphasis that time itself, independently of anything else, passes. For its part, the relational theory of passage denies that there is a substantial thing, or a process, or a structure, of time. Rather, time is a relational feature of the world. Events are temporally related in various ways: they might be successive, simultaneous, have certain intervals among them, and so on. In addition to these events and their relations, there is no entity of time that stands of its own.

It is not clear who was the first, or among the first to develop a relationist ontology of time.[1] Some, for example, Bardon (2013), dub Aristotle relationist. In his interpretation, Aristotle espouses a variant of relationism, which analyzes time in terms of objective relations among events. He refers to Aristotle's description of time as "a kind of number" (*Physics* 219 5–6), more specifically, "a number of change in respect of before and after" (*Physics* 219a 34–219b 1). Aristotle explains: "So time is number in the sense of that which is numbered, not in the sense of that by which we number. That by which we number is not the same as that which is number" (*Physics* 219b 5–8). In other words, when I calculate that there are five cookies in the jar, I am not implying that there is 'fiveness' in the cookie jar. We use abstract mathematical units to compute and compare individual natural beings, although there are no abstract numbers out

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there. Thus, we may veridically say that whales are bigger than shrimp, or that the Sun is brighter than any planet in our solar system. To reach these conclusions, one does not have to maintain that there are such things as 'biggerness' or 'brightness.' Importantly for time, we may ascertain that the actual playing time of an entire hockey match played in regulation time lasts three times longer than any of its periods (Bardon 2013: 13–4).

There are some reasons to be skeptical of the relationist reading. The following reasoning is at odds with relationism. If heavenly bodies suddenly cease, time would not, for Aristotle, stop. If planets stop, some other things remain in motion. On one reading, Aristotle does not equate time and motion, or time and change in general. This is how Bardon (2013: 13) interprets Aristotle:

> He notes that change is a contingent and local phenomenon, whereas we think of time as passing equally for everything everywhere, no matter what is going on in the immediate vicinity. Further, although changes can be slower or faster, time cannot; "slow" and "fast" are defined in terms of time, not vice-versa. So time cannot literally be change.

Such a description (of *Physics* 218b 10–20, I assume) does not sound like relationism. The idea that time passes equally for everything everywhere sounds a lot like substantivalism. If time has a definite speed, and if this speed is used to define the speed of things, this means that there is a time independent of those things that are being measured. Under relationism, speed may be determined only by comparing the relative speeds of objects, that is, how fast they move with respect to each other. There is no one universal true time that provides a standard for any measures, like speeds of bodies. Such a putative time could not be the basis for the synchronization of clocks, either.

Ursula Coope (2005: 31) notes that for Aristotle time is "something of change." How time and change are connected is extremely problematic. Yet Aristotle directly says that "time is not without change" (*Physics* 218b 21). We perceive time and change together. Whenever perceiving change, we must conclude that time has passed. Even if we are in a completely dark place, and feel no bodily motion, we experience change in our soul and conclude that some amount of time has passed. If there is any change, there is a passage of time. In this sense, time is generally related to change, not only to some particular change (Coope 2005: 39). This part of Aristotle's *Physics* is hospitable to the relationist doctrine, as well as to the thesis of the relational passage of time as developed in this book.

Coope does not call Aristotle's position relationist. She maintains his views may not adequately be compared to contemporary labels, like presentism, the moving spotlight theory, or some reductive theory that reduces temporal order to causal asymmetry. The issues he raises differ from contemporary discussions. Coope thinks we should study Aristotle to see how differently he thinks about time compared to us. This might shed light on some of the presuppositions we have on time (Coope 2005: 3–5).

I am not sure whether Aristotle was a relationist, but there are good reasons to think, as is typically assumed, that Leibniz was. He did not use this world himself. Leibniz's arguments in his third letter to Clarke form the basis for standard relationism (Leibniz and Clarke mid-1710s/1989). In a short sentence in his third letter, we can find Leibniz's (2000: 15) objection to substantivalism as well as his positive relational account: "instants, considered without the things, are nothing at all and that they consist only in the successive order of things." Karim P. Y. Thébault (2022: 386) divides this sentence into a critical and a constructive part. The first half of the quote maintains there cannot be a changeless duration. The second half indicates that time is "the successive order of things." So there is no changeless time itself, but time is somehow a successive relation among things. As Jan A. Cover (1997: 289) points out, for Leibniz, the existence of time is secondary. It is derived from things and the properties they contain. If there is a passage of time, it must be, or so the relationist thinks, derived from the way objects exist.

Leibniz's position stems from a combination of physics, metaphysics, and theology. Unraveling these intricate connections would force me to sidetrack too much from the main issue of this book. Richard T. W. Arthur (1985: 263) encapsulates his position with two points that, according to him, "no one would dispute":

(i) *Time is relational*. That is, time is not itself a physical entity, but is rather a *relation* or *ordering* of such entities as are not coexistent.
(ii) *Time is ideal*. Being relational, time has no existence apart form [*sic*] the things it relates; it is therefore an *ideal entity*.[2]

As per the first point, the relationism developed in this book treats time not as a physical entity but as a relation or ordering of events. This form of relationism is still a form of realist ontology and thus different from the second point. Relational passage is distinct from antirealism or idealism on passage.

## Classical antirealist and idealist arguments

Among the anti-passage classics, Kurt Gödel's 1949 article "A Remark about the Relationship between Relativity Theory and Idealistic Philosophy" ranks among the most important, because he takes the structure of relativistic spacetime on board. He explicitly equates his conclusion with Parmenides and Immanuel Kant. He also refers in a footnote to J. M. E McTaggart's 1908 article "The Unreality of Time," another antirealist about passage (and time in general), which forms the basis for current debates.

Parmenides argued that change is an illusion. If this is correct, the passage of time must be an illusion. In his view, our common beliefs are rife with contradictions. Our ordinary beliefs do not unfold the correct nature of reality. Contradictions both affirm and deny, and so they neither affirm nor deny anything. If Parmenides succeeds in showing that beliefs that treat the world being temporal are contradictory, then, in fact, reality is not temporal (Hoy 1994: 574–5).

The interpretations of Parmenides's argument are based on a fragment of his metaphysical poem, written roughly 2500 years ago (reproduced in Palmer 2009).[3] The sixth fragment of the poem reads: "It is necessary to say and to think that What Is is; for it is to be, but nothing it is not" (Palmer 2009: 367). "At the start," Ronald C. Hoy (1994: 575) remarks, "it is safe to assume 'it' refers to whatever it is that is real." A central difficulty that occupied the pre-Socratics was how words correspond to and correctly describe something that does not exist. Applying this to the ontology of time, we may ask how temporal locations like the past and the future exist. Can one include different times in one's ontology? How do these different temporal locations change?

This battery of questions is particularly relevant for passage. On pain of contradiction, nothing cannot become something, and something cannot become nothing. Thus, Parmenides asks in the eight fragment: "And how could What Is be hereafter? And how might it have been?" (Palmer 2009: 369). Here he has introduced the problematic tensed locations of future and past. "For if it was, it is not, nor if ever it is going to be: thus generation is extinguished and destruction unheard of" (Fragment 8, Palmer 2009: 369). It is illogical to say that the real present moment becomes a nonexistent past or that a nonexistent future becomes the real present moment.

We think of different temporal locations from the present perspective. Yet the different temporal locations, the past and the future, do not exist. Describing the world with tensed language and thought leads to a contradiction. Unlike his predecessor Heraclitus, Parmenides thinks there are no contradictions: reality is not inherently contradictory. Nature is truly static and changeless uniformity: "What Is is ungenerated and deathless, whole and uniform, and still and perfect.... And remaining the same, in the same place, and on its own it rests, and thus steadfast right there it remains" (Fragment 8, Palmer 2009: 369). Reality is ultimately a globe-shaped unity, which does not change.

Hoy (2013: 18) elucidates the problem in the notion of change from a Parmenidean perspective. He describes a simple case in which someone lifts their arm from a lower position to a higher position. Let this be a student raising their hand in a classroom to ask for permission to speak. Say the lifting of the hand is rapid. Typically, we would say that we saw the whole process take place instantly or that the hand moved all at once. We could say that we saw, but did not infer, that the hand moved from low to high. At the beginning of the process, the hand is at the student's desk. At the start, this position is "what is." Any other position is "what is not." Eventually, the student's hand is above their head, and their hand points toward the ceiling. At the end, this position is "what is," and all other positions, including the student's hand at the desk, is "what is not." If we could see the motion of the hand at one instance of time, the hand would be both on the desk and above the head. In this case, one is trying to say both that hand being at the desk and above the head are the same and not the same (Hoy 2013: 18–9). Parmenides contended in the sixth fragment of the poem that uneducated notions suppose "that it is and is not the same and not the same; but the path of all these turns back on itself" (Palmer 2009: 367). The flux of time is self-contradictory. "Therefore," notes Hoy (2013: 19), "it cannot be real, cannot be what is." Parmenides's reasoning entails that reality is completely absent of temporal becoming. There is no passage of time.

For Kant, time is an *a priori* form of sensibility. In the interpretation of Adrian Bardon (2013: 33), Kant emphasizes the adverbial application of the concept of time. We experience things temporally, not in time. In his transcendental exposition of the concept of time in his first *Critique*, Kant concludes that

> [t]ime is not something that would subsist for itself or attach to things as an objective determination, and thus remain if one abstracted from all subjective conditions of the intuition of them (KdRV A32/B49).... Time is therefore merely a subjective condition of our (human) intuition... and in itself, outside the subject, is nothing (KdRV A35/B51).

According to such idealist metaphysics, reality itself is atemporal. In Kant time is not an innate idea. Instead, we humans impose temporality onto the phenomenal world. How this happens exactly is a matter of Kant exegesis, which is not my main concern here. Roughly and broadly, the Kantian view is that the noumenal world lacks time altogether. The passage of time is a subjective human phenomenon.

McTaggart, very much in the Parmenidean way, maintains that tensed language and thought are contradictory. The A-series is contradictory because an event cannot have all three A-predicates, to wit, past, present, and future. Thus, McTaggart (1908: 468) puts it as follows: "Past, present, and future are incompatible determinations. Every event must be one or the other, but no event can be more than one." A-series contains a contradiction, so it may not in reality exist. The distinction of tensed locations "is simply a constant illusion of our minds" (McTaggart 1908: 458). In the absence of fundamental tensed locations, there is no room for passage: the future does not become present and then become ever more past.

Relativistic spacetime and passage are enemies, not allies—at least for Gödel. For time to pass, Gödel (1949: 558) thinks, reality should be made of "an infinity of layers of 'now' which come into existence successively." The problem with this view is that there is no unique way to foliate a relativistic spacetime. No hypersurface of simultaneity that extends without limit on a spatial axis exists. If two space-like separated events are not connected with any signals, they cannot both be said to happen 'now.' What occurs right now is local and relative to the designated frame of reference. As spacetime cannot be foliated into objective spacelike layers, one cannot stack them up either. The relativity of simultaneity, in Gödel's view, implies the denial of any objective change. There is no universal change from earlier times to later times through a constant new creation of 'now.' Echoing Parmenidean antirealism and Kantian idealism, Gödel (1949: 557) maintained that "change is an illusion or an appearance due to our special mode of perception." Hence there is no real passage of time.

Perhaps nothing ever changes. Whatever there is exists tenselessly. Nothing ever will be, is, or was. It just BE. This was Parmenides's position. Change is an illusion due to our deceptive senses.[4] Kant went on and argued that certain in-built schemas constitute our dynamic experience of the phenomenal world (Bardon 2013: 35–7). Friedel Weinert (2005: 588) defends the compatibility of the Kantian view with relativity:

> The physical universe must be static, a block universe. The Special theory seemed to confirm what Kant had claimed: that time was a feature of the human mind. For Kant, of course, observers always agreed on the simultaneity and time of events, because they were either stationary or moving so slowly that relativistic effects went unnoticed. Correct the Kantian view for relativistic effects, and Kant becomes vindicated by the Einsteinian revolution.

Gödel would by and large agree with the preceding quote. In an essay he did not publish, "Some observations about the relationship between theory of relativity and Kantian philosophy," he notes that "at least in one point relativity theory has furnished a very striking confirmation of Kantian doctrines" (Gödel 1946: 230). His analysis of Kantianism in the essay is quite subtle,[5] but in referring to section B49 of the first *Critique*, he agrees that time is neither self-existing nor an inherent ordering in the objects. This implies that reality itself is not temporal. Under such idealist theory, there is no time that marches on independently of subjective human preconditions.

Donald C. Williams (1951) went as far as naming his oft-cited paper "The Myth of Passage." His approach was in part inspired by Hermann Minkowski's four-dimensionalist take on Einstein's special theory of relativity (Campbell et al. 2019). Events are spread across the time axis in a similar way as they are spread across the space axes. Williams holds passage to be a superfluous element to the manifold of events within the four-dimensional spacetime. Events are temporally ordered in certain ways, but in addition to this order, there is no flow of time. Time can be said to flow only in a metaphorical way. When looking at a painting, one might say that there is a flow from a nearer location to a farther one. Yet this is nothing more than receding due to a linear perspective. There is as much rolling or marching of time between events as there is rolling or marching of space among people waiting in a queue (Williams 1951: 460, 463, 467). A static, nondynamic interpretation of the four-dimensional world, which Williams refers to as "the pure theory of the manifold," is the most intelligible account of spacetime. We should reject "the disastrous myth of passage" (Williams 1951: 471).

Not many years after Williams, Adolf Grünbaum launched a vigorous attack on passage. He dismissed notions denoting passage, flow, or flux of time, as well as temporal becoming. In his seminal book *Philosophical Problems of Space and Time* (1973: 324), he claims that becoming is reduced to the awareness of an event by a conscious being: "the coming into being or becoming of an event, as distinct from its merely being, is thus no more than the entry of its effect(s) into the immediate awareness of a sentient organism (man)." Events come to us when we perceive them. Becoming is merely a fact that, for instance, I see a common brimstone flying and a crocus in the flowerbed for the first time in spring. I do not affect the flying of a butterfly or the growth of a flower in any way. I simply become aware of them when I stumble across a location in spacetime that I share with the events. Saying that events come into being does nothing to vindicate the reality of passage. It can with equal plausibility be said that events just BE, occupying specific spatiotemporal regions.

## Substantivalism about passage

In the Scholium to the Definitions of the first book of his *Principia*, Newton separates relative and absolute time. He equates the latter with true and mathematical time. Newton notes that absolute time, "in and of itself and of its own nature, without reference to anything external, flows uniformly." This concise description contains the two essentials of substantial passage. (1) Time exists by itself, without anything else. (2) Time flows equally, so it has a definite metric. The stable rhythm of absolute time provides an impeccable standard for the measures of time. Clock time, for example, is a relative measure of time. For a clock to be accurate, the ticks of the clock must take place at even intervals. The ticks between 1s–2s–3s … 58s–59s–60s must all be equal. The second hand must sweep out its circle at a steady pace. The time it takes for the second hand to sweep out 9h–10h must be equal to the sweeping out 10h–11h and to all other measures of an hour.

We do not perceive perfectly equal intervals of time with our imperfect senses. Artifactual machinery also involves error estimates: no measurement is flawless. True measures of time cannot be based on natural uniformities. The correct standard of synchronization is not anything observable. Notions delineating equal measures of time, like 'even intervals,' 'constant rate,' and 'steady pace,' make sense on the condition that they are compared to time itself, which by its own nature goes on uniformly. Equal measures are equal "with respect to the passage of time itself, that is, with respect to absolute time," notes Maudlin (2012: 15) in explaining Newton's position.

The equal intervals of time can be understood mathematically by considering the laws of motion. I have reproduced an idealized motion diagram (Figure 1.1), which should be helpful for understanding Newton's argument. Typically, such motion diagrams are used for depicting spatial intervals. Here I have used temporal intervals.

The basic idea of the diagram is simple. (A) When a body is not subjected to a net force, it moves in equal temporal intervals in equal spatial intervals. (B) When a body is subjected to constant net force, it moves in unequal temporal intervals in equal spatial intervals. By looking at the diagram, one cannot see complete equalities or inequalities. Our senses, as well as measuring rods, clocks, and the like, are not error-free. One can see that in (a) the distances between 1–2–3–4–5–6 are roughly the same. In (b) they are clearly different. Since temporal intervals are depicted spatially, one can use a tape measure to reach the same conclusion. Yet no tape measure is perfect. Measuring tapes are constructed with a comparison to a common measure, which is a conventional choice maintained by a heavy international bureaucracy. The same goes for clocks. As Newton has it, such relative and apparent time "is commonly used instead of true time" (*Principia,* Scholium, Definitions). Yet when we consider true time mathematically in concert with the laws of motion, we can easily understand the difference between equal and unequal times.

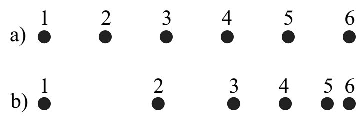


*Figure 1.1* Equal and unequal temporal intervals. In (a), they are absolutely equal, and in (b), they are absolutely unequal. In both (a) and (b), the spatial distances between snapshots 1, 2, 3, 4, 5, and 6 are all the same.

Maudlin (2007: 110) fully endorses the dictum that time,

> 'of itself, and from its own nature, flows equably without relation to anything external'. The phrase, of course, is Newton's characterization of 'absolute, true, and mathematical time' in the Scholium to Definition 8 of the *Principia,* and, properly understood and updated to fit Relativity, I fully endorse it.

In Maudlin's (2002: 259) view, the passage of time "is metaphysically independent of the material contents of space-time." Like Newton, Maudlin maintains that the passage of time is independent of any physical objects or events. The passage of time is independent of external change:

> The passage of time is a fundamentally asymmetric feature of time, in virtue of which all motion and change occurs, that is, things only change because time passes. I believe that time can pass without there being any change, or any other change than the passage of time itself, i.e. change in what time it is.
>
> (Maudlin 2018: 1808)

His substantivalist position is however revised because "the passage of time is an intrinsic asymmetry in the structure of space-time itself" (Maudlin 2002: 259). A typical Minkowskian metaphysical interpretation of special relativity, or a physics textbook exposition is that time, here defined simply as the ticking of clocks, and space, here defined simply as the length of rods, are not absolute. Spacetime is however absolute. Across inertial frames, temporal and spatial intervals are not the same, $\Delta t \neq \Delta t'$ and $\Delta x \neq \Delta x'$, but the spacetime interval, $c^2(\Delta t)^2 - (\Delta x)^2$, is invariant. Maudlin subscribes to a block universe view and declines presentism (though to my knowledge he does not explicitly endorse eternalism).

Maudlin tackles what is a common objection against the reality of passage, namely, the putative inconsistency of its rate. If time passes one second per second, there is no real unit that relates to time's speed. In $1s/s$, the seconds cancel out, so $1s/s = 1$. Huw Price (1996: 13) notes: "A rate of seconds per second is not a rate at all in physical terms. It is a dimensionless quantity, rather than a rate of any sort."[6] The core difficulty for the substantivalist is to measure the speed of something self-existing, something that goes on "without a reference to anything external," as Newton described the absolute flow of time. Markosian (1993: 837) explicates this principal difficulty:

> For any time-dimension, T, if T *flows* or *passes*, then there is some time-dimension, T′, such that T′ is distinct from T, and the flow or passage of events in T is to be measured with respect to T′.

In case some flow may be compared to a stationary background, the rate of flow is not a problematic notion. A river flowing five kilometers per hour means that the contents of the river move five kilometers in some direction in an hour relative to the riverbank. After an hour of flow, the contents are five kilometers farther from the place they left from and five kilometers closer to the place they are heading to. Given this comparison, Maudlin notes there is nothing strange about the flowing of time. Considering our lives, our temporal positions change in an hour's time: we are an hour closer to our deaths and an hour farther from our births. "So," Maudlin (2002: 261) has it, "time does indeed pass at the rate of one hour per hour, or one second per second, or 3,600 seconds per hour."

To expound on his position, Maudlin (2002: 262) makes a comparison between the passage of time and the exchange rate of currencies. By *a priori* necessity, the correct conversion rate is any given amount of currency for the same amount of the same currency: one dollar per dollar, one euro per euro, one krone per krone, and so on. One main currency unit should correspond exactly to another main currency unit. Both have the same amount of purchasing power. It is not meaningless to define the rate of change of main units as unit per unit; what would be meaningless is to provide any other exchange rate. Some one-dollar bill buys the same commodity as any other one-dollar bill will. Time passes equally means that one passing of time is equal to another passing of time, one hour is equal to another hour.

Maudlin takes up Gödel's challenge. Gödel denied passage because relativistic spacetime may not be foliated into objectively determined layers. He provided a solution to the Einstein field equations that indicates that spacetime may not even be split up into spacelike hypersurfaces. The first issue Maudlin criticizes of Gödel's antirealist/idealist position about passage is the claim that the 'objective lapse of time' should be defined as piling up of subsequent 'now's. In the view of Maudlin, passage itself provides the ultimate distinction between past and future. Say a body moves from point *A* to point *B*. The one end of the body's worldline has *A* in its vicinity, and the other *B* in its vicinity. This distinction does not involve a foliation of spacetime. If passage of time is something primitive, it itself grounds the direction of time from past events to future events. There is some lapse of time between the body's motion from *A* to *B* (which is measured by the invariant proper time; more about this in the next chapter). The lack of foliation does not show that time does not pass from earlier to later. "It is the direction, not the foliation, that is doing all the work" Maudlin (2002: 266) has it.

To argue for one-directional passage, Maudlin refers to the cone-like structure of Minkowski spacetime. The separation of the two cones enables one to decide whether the body moves from *A* to *B* or from *B* to *A*. Separating future and past light cones is not enough for the direction of time. Many have argued that laws of nature are symmetric, so thermodynamic considerations based on the past hypothesis give time its arrow.[7] Maudlin disagrees with the implication of the time-reversal invariance thesis, even and especially concerning the fundamental domain. He alludes to the violation of the so-called CP-invariance. The subtleties of fundamental particle physics are beyond the competence of this author. What is important here is that there is an experimental result, which is relevant to the ontology of time. In the following, I follow Paul Halpern's (2018) popular exposition on the violation of CP-invariance.

Within the realm of subatomic quantum physics, many researchers have believed that all processes are time-reversal invariant. The scattering of electrons from each other looks the same whether run backward or forward in time. Yet in certain rare modes of decay, like in the decay of neutral kaons, the charge parity invariance breaks down. This was shown experimentally by James Cronin and Val Fitch in 1964, which earned them a Nobel prize in 1980. Before them, Chien-Shiung Wu (1957) and her group demonstrated the breakdown of parity. Typically, it is possible to manipulate interacting particles in a way that changes their charges from $+q$ to $-q$, or from $-q$ to $+q$. When this process is reversed spatially, an electron moving to the right toward its antimatter counterpart should look like a positive charge moving left, away from a negative charge. After this process is reversed in time, the two charges attract each other. The whole process is symmetrical and hence mute on the direction of time. Cronin and Fitch demonstrated that the time-forward and time-reversed processes are not equally plausible in the case of kaons' decay. "Nature," Halpern (2018) sums up the implication of the experimental finding, "even at its deepest level, might have a preference for a single temporal direction."

Deep down, laws might be asymmetric. Yet even in cases in which charge conjugation and parity transformation hold, the direction of time is not inverted. Say there is a particle that is positively charged, $+q$, and it moves to a positive direction with a velocity $+v$. We may mark the direction of time in this case with $+t$. CPT symmetry provided, a mirror image of this scenario would look like a negatively charged particle, $-q$, moving in a negative direction with a velocity $-v$. We may mark the direction of time in that case with $-t$. Physically there is only one motion: a mirror image retains everything physically salient in the scenario. Yet changing $+t$ to $-t$ is superficial: it does not refute the idea of a temporal direction. Consider the following toy example.[8] One could set up an experiment and then imagine what the actual experiment is like in a mirror image. Figure 1.2 is a sketch of the situation.

Even if the parity holds, the direction of time is not inverted. The experimenter may manipulate a particle so to reverse its velocity from $+v$ to $-v$. In reversing the velocity of a particle, they have not reversed the direction of time. How could the experimenter do that? How could they change later times to earlier times?[9]

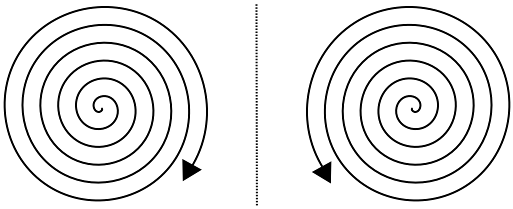


*Figure 1.2* A particle moves clockwise on the left side with velocity +*v*. A mirror image shows a reversed velocity –*v* of counterclockwise motion, as depicted on the right. Reversing velocity does not change the direction of time.

To understand Maudlin's substantivalist view on passage, it is important to pay attention to his NonHumean account of laws and modality. He expresses his position most clearly in the following statement:

> My own view is that the physical laws and the direction of time are both natural candidates for fundamental ontological posits, not admitting of further metaphysical analysis.... Tables and chairs and governments and wars and species are not plausible candidates for ontologically fundamental items. Laws and the direction of time are.
>
> (Maudlin 2020: 526)

Laws of nature are ontologically primitive. As the universe began in some initial state, "the laws of temporal evolution," as Maudlin (2007: 174) calls them, operate "from that initial state to generate or produce later states." These fundamental laws are productive of the Humean mosaic; the world is not merely what David Kellogg Lewis (1986b: ix) thought, "a vast mosaic of local matters of particular fact, just one little thing and another." Maudlin's position stands in stark contrast to Hume's and Lewis's regulatory accounts, which deny, or at least are highly critical of, there being natural necessity out there. Maudlin (2020: 527) treats the necessity of laws as unanalyzable: "the physical necessity of the physical laws is not a deep ontological insight, it is a simple by-product of the semantics of modality." These laws generate future moments of time, whether deterministically or probabilistically.

The necessitarian account of laws, in the view of Maudlin, explains the passage of time. The initial state plus the laws of nature, *explanans*, bring about the mosaic of the world, *explanandum*. The laws produce the temporally subsequent universe as their existence does not ontologically depend upon the unfolding universe. This option is certainly not available to the Humean (e.g., Beebee 2000), as for them, laws are facts about the future. According to Humeanism, laws do not do anything; there are no things called laws deep down that govern the behavior of objects. Maudlin's non-Humean explanation is reminiscent of the covering law model: the initial state of the universe, including its actual laws, explains the future totality of the universe. Because the temporal asymmetry is intrinsic to the fundamental laws of the world, his model is not subjected to the typical counterargument against the covering law model, namely the logical symmetry problem. "The basic temporal asymmetry of past-to-future," concludes Maudlin (2007: 175), "underlines the very notion of production itself." The asymmetry of time itself, the self-sustaining passage, is needed to produce the Humean Mosaic. Without it, the production could not take place. The direction of time must be ontologically independent of the entire structure of the Mosaic.

John D. Norton is also a substantivalist about passage. Very much like Maudlin, his starting point is commonsensical. Despite the prominent anti-realist or idealist traditions regarding passage, the ordinary view is that time passes. Given this approach, it is not strange to say that time passes. What is truly strange is that there is no passing even in the mundane sense of passage of time. In his own words,

> [t]ime really passes. It is not something we imagine. It really happens; or, as I shall argue below, our best evidence is that it does. Our sense of passage is our largely passive experience of a fact about the way time truly is, objectively. The fact of passage obtains independently of us. Time would continue to pass for the smoldering ruins were we and all sentient beings in the universe suddenly to be snuffed out.
>
> (Norton 2010a: 24)

This quote should not be read as indicating that time is a substance. What is asserted is the independent reality of a process, the passing of time. Norton does not mean that time is a thing that passes. I understand his position still in the substantivalist sense: it implies there is a process that is independent of our sensing it. What is the "best evidence" for the reality of passage? Norton acknowledges that passage does not appear in the physical theories. Yet it is a "fact known to us all that future events will become present and then drift off into the past" (Norton 2010a: 24). What is not in our experience of passage is any special moment of 'now' which extends globally in space. He thinks passage is a prominent aspect of our experience, whereas the universal present is a purely speculative notion.

In Norton's view, relativistic spacetime enables us to discern temporal ordering which corresponds to earlier and later stages of some processes. Yet no temporal passing is to be found in spacetime. This does not render passage an illusion. Typically, we have an explanation for why certain illusions take place, and we also know a way to make them disappear.

Consider the finger sausage illusion. Put two index fingers close to your eyes and you see an individual "sausage" floating in the middle. This is an illusion. Norton (2010a: 29) stresses that the passage of time is not an illusion like this. We know the mechanism that is productive of the finger sausage illusion (the gaze direction of the eyes is merged and the brain corrects this by suppressing one end of the finger), and we know how to manage and get rid of it (move your fingers away, shut your eyes, look elsewhere, etc.). We know no mechanism that putatively produces the illusion of passage, and we have no means to stop experiencing passage. How could "the presentation to our consciousness of the successive moments of the world" (Norton 2010a: 24) be illusory like the "finger sausage"?

In Norton's (2010a: 32–3) account, there are two salient factors in our experience of passage. First, we experience the 'now' directly. Our accesses to the past and the future are indirect. We reach the past through memory and the future through various predictive methods. We abstract temporal relations from distinct moments of past, present, and future. Second, Norton contends that we directly perceive the changing of the present moment. How this exactly happens, he does not know, and leaves the details to experimental psychology. He propounds that we perceive the changing of the 'now' in observing motion. In his example, there is one bicycle wheel rotating and another bicycle wheel not rotating. Norton thinks we can instantaneously see the difference between the moving and the motionlessness objects. He surmises that our perception of the present moment is finite but short, less than a second. Within that time span we acquire the perception of motion. This constitutes the moment 'now' in our experience. The experience of the present moment does not give us information about the passage of time, but the entirety of our changing perceptions does.

In this context, Norton does not refer to David Hume, but it is evident his views come close to Hume's reasoning in the second part of the first book of his *Treatise*. In his analysis of the idea of time, Hume concludes "that time cannot make its appearance to the mind, either alone, or attended with a steady unchangeable object, but is always discover'd by some *perceivable* succession of changeable objects" (T 1.2.3.7; SBN 35). Hume maintains that we get the idea of time by a succession of perceivable objects. If we do not perceive anything successive, we do not get time's idea, including the idea of passage. Think about someone in a sensory deprivation tank. Without sensory input, they do not perceive anything that might be the source for the idea of time. The surrounding does not give the notion of passage. In a sensory deprivation thank, it is extremely difficult to tell how much time has passed, because there one does not perceive any relative change. Yet one may splash the high-buoyancy water, feel own's bodily motions, and so on. Thoughts are going on in the mind. This gives some notion of passage.

Here is Norton's (2010a: 33) analogy. He first refers to "the idea of the totality of our perceptions of changes underway in the present moment." Then he comments:

> Even if we are in an environment that it [*sic*] totally static – an empty, noiseless doctor's waiting room – we still perceive our own bodily functions changing, such as our breathing and heartbeat, and even the process of our thought.

Even in cases like these, the changing surroundings are evidence of the passage of time. Norton infers (although the details of this inference are not clear to me) that passage continues inevitably even in the absence of anyone experiencing changes.

## Relational passage

Although Norton's characterization of the passage of time eventually sounds like Hume's relationism,[10] the substantivalist theory is Newtonian in spirit. Newton thinks it is a popular misconception that quantities like time could be "conceived solely with reference to the objects of sense perception" (Scholium, Definitions, first Book of the *Principia*). To get rid of such a misconception, one needs to differentiate absolute/relative, true/apparent, and mathematical/common quantities. This is very different from Hume the concept empiricist. In a footnote (T 1.2.5.26n12; SBN 638–9) in which he discusses the epistemology of the ideas of space and time, he pronounces his empiricist creed:

> As long as we confine our speculations to *the appearances* of objects to our senses, without entering into disquisitions concerning their real nature and operations, we are safe from all difficulties, and can never be embarrass'd by any question.... If we carry our enquiry beyond the appearances of objects to the senses, I am afraid, that most of our conclusions will be full of scepticism and uncertainty.

Around and after the advent of relativity, positivists took on Hume's concept of empiricism. They formulated their epistemic views to suit the aspects of modern physics they understood in positivist terms. At least they interpreted physics in positivist terms. Moritz Schlick's and Albert Einstein's 1915 correspondence is a good example of this. In his denial of absolute time, Einstein (1998: 161) acknowledges the influence of "Mach, and even more so Hume, whose *Treatise of Human Nature* I had studied avidly and with admiration shortly before discovering the theory of relativity."[11] According to strict empiricists like Hume or the positivists, absolute time is either non-observable entity of which we should remain agnostic of or treat it as a meaningless item of unverifiable metaphysics.

Logical positivism, at least in the formulation of its early proponents in the Vienna Circle, has largely been rejected by contemporary philosophers.[12] Absolute time cannot simply be revoked on the basis that it is unobservable or metaphysical in nature. Devising an ontology of time is to engage in metaphysics, whether the ontology includes an absolute structure or not. I think the non-observability is still a problem for the substantivalist. We observe changing processes in our minds, bodies, and our environment all the time. We do not however observe time itself. We do not perceive substantial time—if there even is such a thing—undergoing change. The putatively self-existing flux cannot be sensed, measured or manipulated in any way. Maudlin (2012: 46) anticipates this objection:

> physics is evidently in the business of postulating unobservable entities in service of explaining observable behavior. The postulation is always risky, but, as the atomic hypothesis illustrates, the risk can sometimes pay off handsomely. Newton knew that absolute space and time are not, in themselves, observable, but he also explained how postulating them could help explain the observable facts.[13] Why is this any worse than postulating atoms?

The atoms have become detectable by means of various technologies since the dawn of the 20th century. Today, it is hard to imagine how there could even be modern science if there were no atoms. Not only does high-energy physics evidence their existence, but there are also various fields like chemistry and medicine that utilize atomic structures. Nothing like this has happened regarding detecting, observing, or experimenting with time itself. We have never sensed or measured a self-sustaining flow of time. To the best of my knowledge, no scientific inquiry requires absolute time (some might require absolute spacetime). One does not have to be radical concept empiricist like Berkeley or Hume, or an anti-metaphysical positivist to say that there is no empirical evidence for the passage of substantial time *and* that this lack of evidence is problematic.[14]

There is plenty of evidence for the relational passage of time. Our environment is rife with change. It is controversial whether time requires change. Sydney Shoemaker (1969), Robin Le Poidevin (2010), and Matteo Morganti (2017) argue that it does not. During some intervals of time nothing could be undergoing change. Time might pass without change. This idea finds support in Shoemaker's thought experiment. In this hypothetical scenario, there are three regions that are susceptible to "local freezes." Nothing happens during a local freeze: "all processes occurring in one of the three regions come to a complete halt; there is no motion, no growth, no decay, and so on" (Shoemaker 1969: 369–70). Within a local freeze, the observers do not note anything. When the local freezing ends, observers in the local freeze continue as they would. They finish off their paused sentences, slurp their coffees, and see how projectiles go on as they used to. However, they would see processes in other regions very differently. Seasons would have changed, years gone by, and saplings grown into full trees. If one may go through a local freeze, there might be time without change.

Shoemaker's argument shows that it is logically possible that there are local temporal intervals without change. Perhaps the closest real-life example of this is cryonics. Although successful cryonics preservation and revival is currently sci-fi, several people are currently cryo-conserved. Unlike in Shoemaker's local freeze, a frozen person's body is not disjoint from its surroundings. The frozen body is not completely changeless as molecules move constantly around.[15] Yet if the person, after freezing, gains consciousness, there would have been a lapse of time even if (almost) nothing changed in the person's body. If cryonics procedures turn out to be practically possible, the following scenario might take place: someone suffers an injury, loses their consciousness, and, after a successful cryonic preservation, ultimately regains their consciousness. This person could have moved through a temporal vacuum without noticing it. They could not know this by introspection; their only evidence would come from the testimony of others. In the context of Shoemaker's argument, what is essential is that if such local freezes are possible, then a global freeze should be possible too.

Morganti argues that relationism may be formulated without change. He first notes that perhaps temporal vacua are possible even within the definition of relationism. The basic definition of relationism is that time is nothing over and above temporal relations like before $x$ and after $x$. Let the local freeze be $x$. Before $x$, there is change, some dynamic event. Then $x$ takes place, and it has a certain duration. Posterior to $x$ there is another dynamic event, brought about the earlier event that precedes $x$. There are events that occur one after another. This is the source of the passage of time for the relationist: the succession of events is an instance of change. Between the successive events, there is nevertheless something that does not change. Still, within the temporal vacuum, time passes from an earlier stage to later. Time might pass in some regions that themselves do not undergo any change. Perhaps an aggregate of the local freezes makes up the entire universe that is frozen. Time would not stop in that case. This is, in essence, Shoemaker's argument. Morganti holds that qualitative change is not needed: events may follow one another without change by being merely numerically distinct.[16]

Ken Warmbrōd (2004) questions the inductive evidence in favor of a global freeze. In every empirically distinguishable case, at least one area of the universe is not frozen. Even if the universe came completely to a halt, no one could tell that it was under such stagnant condition. Warmbrōd (2004: 281) notes that we could not conceive of a completely changeless world. When we conceive of something stationary, we inevitably compare it to something changing. Think of motion. It is a comparative phenomenon. Inertial motion is relative; whether an object moves or not depends on the choice of the frame of reference. We might say that an object moves in relation to a still object. But how could we conceive of the whole world as utterly changeless? To understand that something is inactive, there needs to be some thing that undergoes change while the steadfast thing does not. As we cannot conceive of scenarios that justify the postulation of time without change—at least on a global scale—any speculation that describes the world as not subject to change results in a world that lacks time.

Moreover, it is not clear how Shoemaker's anti-change view accounts for measuring the interval between the beginning and the end of the freezing zone. Warmbrōd (2017) criticizes Shoemaker based on the clock-law account of time measurement.[17] My criticism of Shoemaker does not rely on the clock-law theory of accuracy. Rather, one might argue that measuring a local interval is impossible without an external measure of change. Clocks are synchronized with the aid of various natural uniformities. Our agreed master clock is based on the transition among two hyperfine levels of the cesium-133 atom's ground state (Dowden 2021; Tal 2016: 301). This standard is neither unique nor necessary, but it is chosen conventionally on pragmatic reasons. Throughout history, humans have used a plethora of standards for keeping time. What is common to all synchronizations is that clocks somehow keep up with the standard. Both the clock and the standard are typically some sort of cyclical processes (they must not be cyclical processes; linear would do fine).[18] To get back to Shoemaker's argument, the problem is that we have a device that measures time based on some changes. Originally the clock is constructed by a comparison to some change. Then a particular clock, which undergoes change in its cyclical measurement, is compared to a stationary object. In Shoemaker's case, it is the local freeze. Even though one allows that there is a local interval not subject to change, measuring its temporal length is not conceivable without any change. As Michael Scott (1995: 216) shows, the whole idea of measuring a local freeze collapses if we accept the global freeze because "there is no change by which to measure the time elapsed."

Without change, understanding the laws of nature would also become problematic. Warmbrōd (2004: 279) claims that

> [p]hysical laws of the actual world often describe the way objects behave *over time*. Photons of light travel the vacuum of space at the fixed rate of approximately 300,000 kilometers per second. Atomic nuclei are inherently unstable and decay over time, emitting radiation. To arrest such changes would be to abrogate principles that are central to our understanding of the physical world.

Here it does not matter whether one's metaphysics of laws is Humean or not. For the necessitarian, the laws of nature govern the behavior of physical objects, and hence, they determine (whether by unique or statistical outcome) the future state of the world. For the non-necessitarian, laws are generalizations over regularities. Laws take the form they do simply in virtue of the course of nature itself. Processes repeat over time.

McTaggart was an antirealist about time, a position that is different from the realist relationism of this book. In any case, I think he was right in insisting that if nothing changes, there is no time: "A universe in which nothing whatever changed (including the thoughts of the conscious beings in it) would be a timeless universe" (McTaggart 1908: 459). Even if there are local freezes within the universe, there are other areas that are not frozen. The changeless area is somehow compared and defined with respect to other parts of the universe which are dynamic. If the whole universe is frozen, there would be nothing temporal in it.

Although there might be some time without change, it is not so the other way around. Change requires time. When a leaf turns from green to brown, there is a change from an earlier time to a later time. The leaf is first, at an earlier time, green, and then it is, at a later time, brown (Oaklander 2004: 41–2). The simple, in this case perfectly common-sensical explanation, is that between the leaf's two states time passes. There is a temporal asymmetry between the two states of the object, and at least some positive amount of time passes from an earlier time to a later time. I will get back to the problem of the direction of time later, as I think the temporal asymmetry is founded on causal asymmetry, which requires a proper analysis of the direction of causation.

According to Maudlin's and Norton's substantivalist accounts, time passes itself, independently of any observers. I take this to mean that there is only one passage of time. For how could time itself pass if it were not one definite process? Katherine Fazekas argues that in case there is no universal temporal order of all events in spacetime, there is no universal B-series, either. The only genuinely successive events are time-like related. Across the universe, there are countless B-series. In Fazekas's (2016: 216) view, "time passes in each of the multiple B-series, but there is no passage of time spanning across all events." The revisionist position entails that passage takes place along an observer's timelike worldline, in which events are arranged successively. Time may only pass among timelike separated events because an earlier event somehow brings about the later event. Causal relations between events do not exist among spacelike separated events, as this would require superluminal transmission. Fazekas's argument provides a strong reason to reject the view that there is only one passage of time. There is an indefinite number of observers who have their own passings of time, and no passing is privileged. The number of B-series does not have any well-defined upper limit.

In Newtonian spacetime, there is a unique foliation on which all observers agree. Within the classical framework, we may draw a 'now' slice that connects all events that occur simultaneously. In Minkowski spacetime, there is no unique foliation. Two events that are not connected by any signals do not stand in a genuine temporal relation. A-locations are neither absolute nor universal: there are no self-existing tensed locations across the universe. Someone's 'now' might be someone else's future or past. Hence, the future does not become past via present in any objective sense. However, Fazekas (2016: 219) points out,

> denying that time passes is unappealing. It is counterintuitive to say that changes, such as those involved in the evolution of a species, a chemical reaction, or the hitting of a home run, occur from one time to the next, but time hasn't passed. So, a theory of passage that is compatible with STR is highly desirable.

The relational account infers the passage of time from the dynamic events of the world. This is consistent with the block universe view. Huw Price (1996: 12–3) notes that the block is many times interpreted as static in a confusing way. To avoid this confusion, I think we should juxtapose and properly analyze the difference between Cartesian three-dimensional and relativistic four-dimensional diagrams. This is a topic for the last chapter of Part II, which deals with persistence. Here we might point out briefly that a source of the misconception is the following conditional. If we image four-dimensional spacetime as a three-dimensional, changeless block and image time as a separate vector to this block, we then present the block itself as static. No change could be in the block, because it is unchanging. William James (2014: 151) dubbed it the "iron block," an absolute unity devoid of any chance, purpose, and freedom. James's treatment of the block relates to the issue of determinism, which is different from the passage of time. The defender of passage responds that timelines are part of the block, not external to it. The passage of time is included within the four-dimensional block (Maudlin 2007: 109).

Dennis Dieks argues that Minkowski's spacetime diagram makes sense only on the condition that the diagram records events. In Minkowski's formalism, an event is an idealized point with neither spatial nor temporal extension (Balashov 2010: 41), yet real physical events always have indeterminate durations (Ben-Yami 2019: 1357–8). An event is a dynamic notion.[19] It is something that happens, something that occurs. "It is exactly here," Dieks (2006: 170) claims, "that there is room for 'coming into being' in the block universe. Events come into being by occurring, by happening; what other coming into being be could there be?" Becoming can be equated with the occurrence of events, with the important restriction that such becoming is local along worldlines (Dorato 2006b: 564, 566).

Block universe does not contain any nonexistent events, because they do not happen. Nonexistences never become anything. The block universe view can represent things that come into existence. This manuscript becomes existent because I actively produce it. Events happen successively along an observer's timelike worldline (and they happen without a definite temporal order outside of an observer's light cones). "This proposal boils down to a deflationary analysis of becoming: becoming is nothing but the happening of events, in their temporal order," concludes Dieks (2006: 171).

The notion of an event is important for a theory of passage that is consistent with relativistic physics. I have argued elsewhere (Slavov 2020a) that events are the fundamental entity of relativity. The simplest way to account for this is to consider time lag. An event happens, and then, after some finite time (the shortest time being the emitting of electromagnetic signals), an observer receives information of the event. This process is asymmetrical: the event causes the observer's perception. It happens independently and prior to the receiving of the information. In this case, the physical event is in the observer's past light cone, and the event and its perception are timelike-related.[20]

A-locations are less fundamental than events. Whether an event is past, present, or future, is dependent on the chosen frame of reference. The same goes for indexical spatial locations like back, here, or front, and the frequencies of the electromagnetic spectrum, like the colors blue, green, or red. The proposition 'The grass is green now in here' is a perspectival fact; whether something happens now in here and is green in color is a perspectival matter. Moments of time do not change in the same way as spatial locations or colors do not undergo change. There is no time which by itself changes from future to now to past, as there is no space that by itself changes from front to here to back and as there are no electromagnetic fields that by themselves change from red to green to blue. In case of the passage of time, it cannot be that time itself changes. Instead, events succeed each other. This relational account of passage, in my view, is reconcilable with modern physics, not the substantivalist one. Events, not moments, ground passage.

Even if one concedes what has been said about passage and dynamicity, we are left with some well-known facts about special relativity. It is impossible to posit a global present in a relativistic context. Assuming eternalism, an ontologically open future does not exist. This latter point affects the strong notion of 'coming into being' that is invoked by the eternalist block-theory version of passage. I think special relativity debunks absolute-universal 'now,' and this leads to the notion of a closed future. I do not, however, think that this is detrimental to the notion of becoming. Next, I explicate the challenge from relativity and then get back to passage.

## Relativity and fixed future

Daniel Peterson and Michael Silberstein (2010) argue that the relativity of simultaneity is consonant with eternalism and the block universe. Their strategy lends support to the classical arguments of Cornelis Willem Rietdijk (1966) and Hilary Putnam (1967). They begin by listing two criteria for presentism. For the presentist, (1) only what is present exists, and (2) local existences are simultaneous with spatially distant existences *simpliciter*. This means that if the present moment is afternoon, and someone in the afternoon eats a snack, then that present moment is exclusively real. The past lunch is no longer real, and the future dinner is not yet real. Moreover, all the events in the whole universe are simultaneous with the person's having a snack. For its part, eternalism denies both (1) and (2). The lunch, the snack, and the dinner all exist. Some distant events might be simultaneous, provided that they are in the same frame of reference, but there is no unique way to slice spacetime with the aid of a hyperplane of 'now.' The distinction between presentism and eternalism is almost identical to the distinction between no-futurism (or as it might be otherwise called possibilism or growing-block theory) and eternalism. The no-futurist thinks the past is real and fixed but the future is open, so a defender of this view would not fully accept (1). For the no-futurist, the past lunch exists, but the future dinner does not. Yet no-futurism is committed to (2): they must accept that the present is definable by a universal knife-edge hyperplane that extends on a spatial axis throughout everything that physically exists.

To show why eternalism is well motivated by special relativity, consider Figure 1.3, which is based on the exposition of Peterson and Silberstein (2010: 214).

Cecilia and Donna share the same inertial frame of reference. Independently of each other, they both sneeze. After this they both go

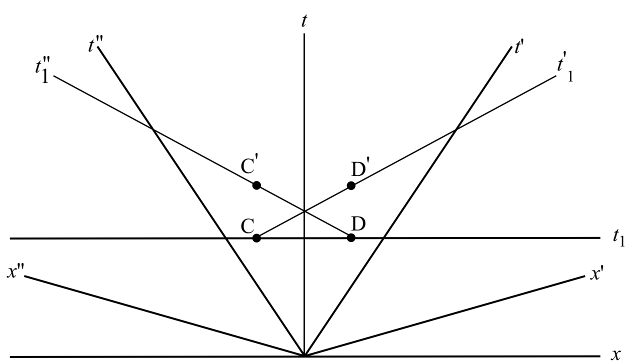


*Figure 1.3* Relativity of simultaneity according to a spacetime diagram. I have drawn this image based on Peterson and Silberstein (2010: 214).

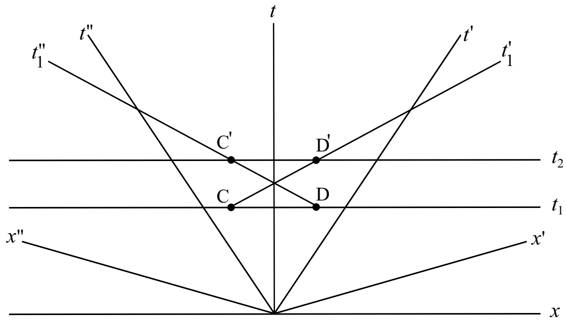


*Figure 1.4* Relativity of simultaneity according to a spacetime diagram (axis $t_2$ added). I have drawn this image based on Peterson and Silberstein (2010: 214).

on, again independently, to wipe their noses. The sneezing of Cecilia is simultaneous with the sneezing of Donna in their common reference frame. Likewise, the wiping of their noses is simultaneous in their frame. To borrow from the notation of Peterson and Silberstein (2010: 215), we may "introduce the symbol '*r*' to stand for 'share and R-value with' or 'is equally real with.'" From the scenario just explained, we get

C*r*D,

Ceci's sneezing is equally real with Donna's sneezing. Both events happen at $t_1$. They are simultaneous and co-real. We could also draw a temporal axis $t_2$, which would indicate

C′*r*D′

Ceci's wiping of her nose is equally real with Donna's wiping of her nose. This much is unsurprising and uncontroversial. Peterson and Silberstein (2010: 215) add a twist to the story. Imagine rapidly moving[21] spaceships directly over Cecilia and Donna. The spaceships pass each other with constant velocity. The frame of the first spaceship is denoted by the primed axis, and the frame of the second spaceship is denoted by the double primed axis. What we get is

C*r*D
C*r*D′
C′*r*D

For clarification, these lines read: Ceci's sneezing is equally real with Donna's sneezing; Ceci's sneezing is equally real with Donna's wiping her nose; Ceci's wiping her nose is equally real with Donna's sneezing. "From the previously established criteria for equal reality," Peterson and Silberstein (2010: 215) point out,

> we can establish two important facts about co-real events α, β, and γ. First, if α*r*β is true, then β*r*α is true since R-values are unique. Thus, the operator "r" is symmetric. This fact must be true since equal reality is an equivalence relation. The second important fact about equal reality is that the co-real operator is transitive, even across frames. That means that if α*r*β is the case and β*r*γ is the case, then α*r*γ must also be the case. This follows directly as [a] consequence of our definition for equal reality.

When transitivity and symmetry are applied in such a way, we get

$$CrC'$$

$$DrD'$$

Ceci's sneezing is equally real with her wiping her nose, and Donna's sneezing is equally real with her wiping her nose. Prior events are as real as later events. We should be careful what this amounts to. In all frames, Ceci's sneezing is prior to her wiping, and Donna's sneezing prior to her wiping. The following four claims are true:

> In no frame does the sneezing of Ceci happen simultaneously with the wiping of her nose.

In no frame does the sneezing of Ceci happen after the wiping of her nose.

> In no frame does the sneezing of Donna happen simultaneously with the wiping of her nose.
>
> In no frame does the sneezing of Donna happen after the wiping of her nose.

Observers can make veridical and frame-invariant claims about what happens before-than or after-than some event. Simultaneously-with is more controversial due to the conventionality of simultaneity; more about this later. But no one can pick out a specific event and label it 'now' *and* truthfully claim that this event is all that exists. All events exist. There is as much reality to the past as there is to the present and to the future. Tensed descriptions of events are perspectival facts.

The view that all time exists, or that all times exist, is akin to the view that all space exists, or that all spaces exist. The four-dimensionalist view is important for developing a view on the persistence of objects in spacetime. This is the topic for the last chapter of this book, but here I should say something about how our intuitive thinking might resort to presentism. The way we think of the relation between spatial and temporal dimensions is relevant for the presentist/eternalist debate. The intuitive Cartesian view is that an object is in three-dimensional space. A stationary object just "sits" there and endures. According to the four-dimensionalist picture, objects have temporal parts along their timelike worldline. Ceci and Donna are made of temporal parts. Their sneezing takes place and is productive of wiping their noses along their worldlines. Both the sneezing and the wiping exist, as well as everything between their births to their deaths exist. And of course, when we think this in a cosmic scale, to quote Sam Baron, "all times from the big-bang to the heat death of the universe exist equally."[22] Saying that all times exist is not categorically different from saying that all of space exists. I think the latter is easier to accept from a commonsensical point of view than the former, but ontologically it can be argued with good reasons that there is no major difference.

Using relativity of simultaneity to ground eternalism has been criticized as the argument relies on hyperplanes of simultaneity. Where do we get the hyperplanes in the first place? How do we know that two spatially distant events happen at the same time? An event is 'now' with respect to itself in the same indexical sense as I am 'here' with respect to me, but how can we ascertain that the event is also 'now' with respect to another event (Brading 2015: 15)?

In his original publication of special relativity, Einstein notes that the invariance of the one-way speed of light is based on a convention. This is evident when we consider the synchronization of clocks. If two clocks, A and B, are separated by a considerable distance, how do we know that they show the same time? We might synchronize them with light signals. If in A's vicinity in space there is an event, we may say that it happened at a certain time, call it A-time. If in B's vicinity there is an event, it happened at a B-time. All the observer at the location needs to do is to compare the local event to the reading of the local clock. Although by this we have defined local A- and B-times, we have not at this point

> defined a common "time" for A and B, for the latter cannot be defined at all unless we establish *by definition* that the "time" required by light to travel from A to B equals the "time" it requires to travel from B to A (Einstein 1923: 40).

If there is a light signal that travels from A to B and then back from B to A, we may repeatedly measure its roundtrip time and conclude that it is constant. We cannot however directly measure the isotropic speed of light. All measurements of the speed of light, like the notorious Michelson–Morley experiment, are based on the condition that light rebounds from some surface. Einstein suggests we could use the following method of synchronization. The light leaves at A-time, $t_A$, from A toward B. It arrives at B at B-time, $t_B$. It is reflected from B back toward A, and so its time of return is $t'_A$. What we have here is a synchrony convention: the pair of clocks synchronize if $t_B - t_A = t'_A - t_B$.

In Einstein's popular book on special and general relativity, in the chapter "On the Idea of Time in Physics," the conventionality thesis is clearly expressed. That light takes the same amount of time to traverse A→B and B→A is "neither *a supposition nor a hypothesis* about the physical nature of light, but a *stipulation* which I can make of my own freewill in order to arrive at a definition of simultaneity" (Einstein 1920: 27–8).[23] Dieks (2012: 618–9) sums up the worry for the eternalist:

> If simultaneity is purely conventional and lacks metaphysical significance, there is obviously no reason to suppose that simultaneous events share a special "reality-property", so that the Rietdijk/Putnam argument seems to become a non-starter.

In his later years, Einstein (1949: 60) went as far as to claim that "there is no such thing as simultaneity of distant events." Rovelli (2019: 1328) notes that the Rietdijk/Putnam argument misinterprets the relevance of the relativity of simultaneity: "Einstein's simultaneity is not a discovery of a fact of the matter about multiple simultaneity surfaces: it is the discovery that simultaneity has no ontological meaning beyond convention." Peterson and Silberstein (2010: 213) obviously apply hyperplanes in their argument for eternalism. It is, however, problematic to assess the simultaneity of two events that are even cosmically speaking very near each other. Say the two events are my writing with my laptop and the Curiosity taking a picture on Mars. As the two are not connected by any signals, they are not genuinely temporally related. If the rover takes a picture and sends it to us, we may conclude that it was taken before we receive it. In this case, the pair of events are timelike-related, and no hyperplane connects them.

Although hyperplanes are not fundamental features of spacetime, this does not mean that they are meaningless.[24] They might be useful ways of carrying out research. Kip S. Thorne (1988: 574) points out that "there is no natural, preferred way to split spacetime up into space plus time." However, in Thorne's account of scientific practice, astrophysicists and experimental physicists many times treat situations in which spacetime is nearly stationary. In such circumstances, there might be non-arbitrary ways to do three-dimensional space plus one-dimensional time slices.

I think there is a way to defend eternalism without hyperplanes.[25] Establishing simultaneity within a specific frame of reference is possible, although the isotropic speed of electromagnetic signals could be an assumption that cannot be proved. One way to account for this is to note that simultaneity is different from apparent simultaneity. I analyze this point thoroughly when assessing temporal fictionalism in the second-to-last chapter of Part II. Think of a case in which there is one observer under a tree and another one, say two kilometers from the tree. Lighting strikes the tree. For the (unfortunate) observer under the tree, the flash of light and the sound of the thunder occur simultaneously. For the distant observer, the light flash looks to take place first, and then, after approximately six seconds, they hear the thunder. In this case, the distant observer must conclude that their perception is not veridical concerning the temporal order of the original cause. They perceive the light and sound at different times, although initially, the two start from the tree at the same time. One might be right or wrong, within a particular frame, about the temporal order of events. The case of thunder striking is of course different from distant simultaneity, because the thunder striking the tree is one event. We are not talking about temporal simultaneity but about temporal identity. Even though there are two events at opposite directions, an observer might separate apparent simultaneity from the simultaneity of events (see Figures 5.1 and 5.2, for clarification). Once the frame is specified, and the isotropic speed premise adopted, observers can correctly conclude in which temporal order the events take place.

This enables one to formulate a rather simple argument for eternalism. If in one frame the temporal difference between two events is zero, the two events occur simultaneously. If in another frame the temporal difference between the two events is not zero, the two events occur successively. If in yet another frame the temporal difference between the two events is not zero, the two events occur successively, and they might occur in reverse order compared to the previous frame. If in inertial frame *IF*' two events are simultaneous, $\Delta t' = 0$. For $\Delta t \neq 0$, because $\Delta t = v\Delta x'/c^2\sqrt{1-\beta^2}$, in which $\beta = v/c$ and $\Delta x' \neq 0$, $v \neq 0$, so $\Delta t$ is a positive number. For *IF* the events are successive; for *IF*" moving to opposite direction to *IF* they could happen in an opposite direction. This relativity of temporal order is not restricted to special relativity. As with relative inertial motions, gravitational differences yield different temporal orders. The temporal order of spacelike events is relative both in the special and the general theory. Note that this is the case with other relativistic quantities, like electromagnetic spectrum frequencies. The received frequencies are evidently relative due to relative inertial motion, and unproblematically the received frequencies are relative due to gravitational effects. Although the cosmological redshift can be properly understood in the context of general relativity, it does not alter the fact that electromagnetic spectrum frequencies are perspectival in the ontological sense. As with Lorentz transformations in the context of special relativity, the equations for the Doppler effect show how the received frequency is relative (Slavov 2020a: 1403).

To elucidate the relativity of A-notions of past, present, and future, consider these two events that occur in my kitchen. 1: Dishwasher starts; 2: Water boils over from the pot on the stove. I am at rest with respect to

1 and 2. For me, 1 and 2 are simultaneous. An observer moving toward the dishwasher would judge it to start before the water boiling over. For them 1 happens before 2; 2 is their future. An observer moving toward the pot would judge the water to boil over before the dishwasher starting. For them, 2 happens before 1. 1 is their future. The observers agree on the existence of events: The dishwasher washes the dishes, and the hot water spills over no matter what. The observers do not affect these physical events in any way. They happen at a distance to them; there is no way for anyone to influence them. The observers do not fully agree on the A-locations of the events. For one observer, 1 and 2 happen presently, for the second 1 happens presently but 2 is future, and for the third 2 happens presently but 1 is future. The second and third observers could disagree also on the pastness of 1 and 2. If in one frame two events occur 'now,' they do not occur 'now' in (almost all) other frames. We may meaningfully say that someone's 'now' is someone else's past or future without postulating hyperplanes.

There is yet another strategy for the eternalist. This is based on considering the structure of the Minkowski spacetime and then showing that because presentism cannot even get started, we should opt for eternalism. In the formulation of Yuri Balashov (2010: 2–3),

> since the geometry of Minkowski spacetime does not support a frame-invariant notion of simultaneity, it does not allow one to define the concept of *the present*. And without such a concept, presentism cannot get off the ground. To put the point vividly, the presentist is committed to the following: when I click my finger on Betelgeuse Boris Yeltsin is either alive or dead. But according to special relativity, there is simply no fact of the matter. There is no global present moment cutting throughout the entire universe that has more than a frame-relative significance.

The basic logic is that of disjunctive syllogism. If it is the case that either presentism ($P$) or eternalism ($E$) is true, and the former is false, then the latter is true:

$$P \vee E$$
$$\neg P$$
$$\therefore E.$$

As indicated earlier, presentist must hold that whatever exists 'now' is simultaneous with everything that exists in the whole universe *simpliciter*. This is a bold assumption since we cannot even ascertain that what happens on Earth and on Mars happens at the same time. There are no unconditional facts about distant simultaneity. Yet physical events exist as they do. In other words, the events exist tenselessly. It is from some perspective that they can be denoted to be in the past, in the present, or in the future. There is nothing unique or ontologically special about the 'now.'

I agree with the upshot of Peterson's and Silberstein's argument. However, it is very clear that as it is based on the Rietdijk/Putnam argument, it stipulates hyperplanes to connect distant events. I understand these to be pedagogical tools for understanding the ontological implication of the theory. Thorne's comment indicates that they are also useful devices for empirical research. Rovelli (2019: 1328), for one, thinks the conventionality of simultaneity subverts presentism, but it does not force us to accept eternalism. I concur that there are no knock-down arguments on either side. Considerations from conventionality and relativity of simultaneity do not necessitate eternalism. The arguments set forth in its defense are based on some assumptions that may not be provable, such as the isotropic nature of electromagnetic signals. They however make the prospects for presentism grim. The alternative eternalist ontology holds more promise as it is clearly more hospitable to special relativity.

To my knowledge, there are no weighty reasons why general relativistic considerations should alter the basic eternalist picture. Read and Qureshi-Hurst (2021) analyze various ways in which one could or could not include cosmic simultaneity in general relativity. Although in principle general relativity might allow solutions that retain absolute simultaneity in the class of the so-called Friedman–Lemaître–Robertson–Walker solutions, it does not mean that our actual universe contains such a privileged time. Arguments that refer to the possibility of a privileged spacetime foliation are therefore conditional. We are not, in fact, so-called fundamental observers that register the intervals of cosmic time.[26] Even though general relativity might allow a preferred foliation and, in this sense, the prospects of presentism are not as bad in general relativity as in special relativity, it remains unclear how we could have access to the unique true time. Hence, Read and Qureshi-Hurst (2021: 8113) put it as follows:

> The cosmic scales with which we are dealing when discussing cosmic time—*viz.*, scales of the entire universe—are extremely far removed from our quotidian experience in our world of medium-sized dry goods. More specifically: our temporal experience is, plausibly, a function only of our *local* environment, rather than of the entire universe. Absent argumentation to the effect that we *can*, in fact, have local access to cosmic time, it is not at all obvious that these cosmological notions can do the work of grounding our local temporal experience, as the A-theorist desires.

Although there are problems for further research, Read and Qureshi-Hurst conclude that going from special relativity to cosmological solutions of general relativity does not justify A-theoretic presentism. Gustavo E. Romero and Daniela Pérez (2014) argue that black holes retain the frame-dependence of simultaneity. Blackhole astrophysics implies a local, not global 'now.' The general theory does not, at least in any obvious or radical sense, turn the odds in favor of the presentist.

Relativistic considerations indeed imply a fixed future.[27] The growing-block theory tries to retain our intuition about the fixity of the past and the openness of the future. This strategy, however, assumes that there is something ontologically different between the past and the future. It also maintains a universal hyperplane that captures everything that exists presently. Neither of these points fits with relativity. At first sight, this might imply that there is no free will. This was Rietdijk's (1966: 343) conclusion. If the future is fixed, no matter what we reckon we choose to do, there is only one way the future exists. This is not a book about free will; such a perennial issue has to be treated at book length somewhere else. The eternalist doctrine can be made consistent with various doctrines like fatalism, determinism, and compatibilism. I think a fixed future does not rule out free will. It is consistent with eternalism: that what we choose to do determines the future. Kristie Miller (2013: 357–8) explains this with a helpful analogy on sentient robots.

On the condition that the future is fixed, there are future-tensed statements that are either true or false. Say it is true that there will be a worldwide war in which sentient robots fight each other. How did the world evolve in that state? Well, it became like that because of the decisions we made at an earlier time. There will be a war with sentient robots, partly because we decided to develop the kind of technology that is capable of massive destruction of its own. If we made different choices, the future would have been different. Our choices have causal impact on the world. The world is in a certain way at a later time, partly due to what we make at an earlier time. We, of course, are not aware of all the impact our decisions have. Still facts concerning later times are dependent on what happens at earlier times.

Some aspects of the future seem open to us because the world is so complex. We do not know presently what the world will be after a long time because there are so many relevant factors and variables that should be taken into account. Whether there is a robot war in 2150 is beyond our epistemic access. There is a fact of the matter, but we do not know it. That putative event is so far in the future for us, so we are not able to handle all the complex information involved in various causal processes. What happens in science and technology, world politics, and the like in course of more than a hundred years—we do not know, we may only guess. Perhaps we can list a number of possible outcomes, and so expect what might happen. But there are no accurate predictions on this matter.

The issue is different if the number of variables is drastically reduced. Consider the solar eclipse of January 2094. At this point, in early 2020s as I am composing this book, this a prediction. All measurements involve error estimates. Predictions are less than 100 percent cent certain. Yet this prediction, unlike the war with robots, is based on the consideration of not so many variables. It could be intuitively more appealing to say that the event of the January 2094 solar eclipse is real than to say that the third world war is real. This is due to the enormous complexity of the collective behavior of humans. The more interacting factors and variables there are, the less certain our knowledge of the later times is. This is an epistemic restriction, not an ontological point. The future is as fixed as the past.

It should be added that it remains unclear whether the no-futurist views can actually avoid a fixed future. The growing-block theorist could argue along the following lines. In the Big Bang, laws of nature are fixed. They are responsible for the subsequent states of the universe. Together with the absolute present, there is a fixed past plus the set of laws. These determine the future. Romero (2017: 149) notes that if these laws are deterministic, the future will exist in a determined way. Even though for the no-futurist the future is not, the already existent universe with its laws fixes the upcoming future. So the future will exist in one way only. The no-futurist should demonstrate that ontological determinism is false. To do this, they could appeal to the probabilistic laws of quantum mechanics. The future position of a particle cannot be determined. We may instead assign probability density functions. It is more likely that the particle will be found in some region than other. Anthony Sudbery (2017), in the spirit of Arthur Prior, has developed a temporal logic that is consistent with an ontologically indeterministic open future. Whereas relativistic considerations can be thought to indicate a closed future, the quantum description may be interpreted to delineate an unfixed future. Romero disagrees. He thinks the appeal to quantum probabilities does not yield an open future. The probability of getting one side up of a die roll is 1/6. This probability is fixed before and after the die is rolled. One might say that quantum laws determine the probabilities of future and past states of the world. This claim is however directed at the problem of how deterministic or indeterministic quantum laws are. I think there is a much more pressing issue when arguing for an open future based on any physical laws.

The laws do not denote a special moment of 'now,' or any other tensed location. It does not matter if we look at classical or quantum equations. Neither Newton's second law nor the Schrödinger's equation contain any special privileged moment of 'now.' We may choose some time and designate it 'now,' and then compute later states of the world, or their probabilities. If we know the relevant variables of a particle at a certain time, we may deduce some of its variables at an earlier or later time. There are some complications to this in the quantum description, like Heisenberg's uncertainty principle, the measurement problem, and the like. But we cannot omit the perspectival nature of the 'now.' This is apparent in looking at a calendar that lists days of the week or the months of the year. If you look at the calendar every day of the week, it is obvious that which day counts as 'now' depends on when you assert the propositions "Today is [the day in question]." Calendars or equations of physics do not highlight any kind of presentness. The equations do not tell us what is 'now.' They do not tell us that times earlier than *t* or later than *t* are irreal. The eternalist has no problem in explicating this: laws of nature do not indicate any privileged 'now' because there is no such thing in the universe! The present moment is an indexical notion like the local spatial place.

Lee Smolin and Clelia Verde (2021) argue for a version of presentism suited to quantum mechanics. Everything real is in the present moment. They think "nothing exists or persists, things only happen." An event is brought about by an earlier causal event, which no longer exists. Events have finite durations, during which they cause the following events to occur. There is a transience of present moments. Becoming is "the transition from indefinite to definite." The world is constantly recreated as indefinites turn into definites. Smolin and Verde assimilate future and indefinity, so "the future is undetermined. But we can imagine various paths it might evolve from our present moment, and make bets, or—what is the same—assign probabilities to them." (Smolin and Verde 2021: 5–6). The future does not exist, it will become when indefinites shall turn into definites.

I agree with Smolin and Verde in that our knowledge of the future is on many accounts speculative. There are of course differences in what that knowledge is about. For example, stock market behavior is much more random than many astronomical phenomena. I think their view is both epistemically and ontologically problematic. The future can be thought of as open only on the condition that the present state of the world—including its past, the growing block theorist would add—is all there is. This is a questionable assumption, because it requires absolute simultaneity, a 'now'-slice that cuts throughout all space. We cannot even ascertain that what happens on Earth is simultaneous with what happens on Alpha Centauri. A distance like this is an incredibly tiny parcel of all of space. The presentist, or the proponent of the growing-block theory cannot maintain an ontologically open future without a universal 'now.' There should be a present moment that attaches to all events and with which every observer agrees. Such a 'now' does not figure in our experience or in the laws of physics. Instead, as Norton (2010a: 24) puts it, the concept of a universal present "figures prominently in groundless speculation."

Jenann Ismael (2012) maintains that our temporal phenomenology is hospitable to the idea of an open future. She refers to a particular temporal perspective we have. This is a snapshot taken from the here and now. From the viewpoint of this present moment, the past is fixed, we cannot affect it. It is partially known due to our memory. There is some uncertainty about the past because our epistemic access to it is limited. This uncertainty cannot be resolved by making any decisions. Our present volitions are indifferent to the way the past is. In contrast to the past, the future is understood in potential terms. "When one is looking into the future," Ismael (2012: 163) has it,

> one represents one's own choices in hypothetical form, sees a range of actions that directly or indirectly depend on them, and makes the choice by imaginatively tracing out their downstream consequences and comparing the results. The choice itself is the product of this imaginative exploration and the decision-maker is right to treat it in that context in hypothetical form. Whether one is deciding what to have for breakfast, which route to take to school, or whether to marry, the future is represented as something that—in the most literal sense—remains to be decided. It is represented in the decision context as unrealized potential.

There is, in some sense, a difference between the past and the future which has to do with decision-making. If I want to traverse between two cities with my car that is currently low on gas, I better get fuel so that in my future, I shall arrive at the wanted destination. The fueling of the car is a means to bring about the wanted outcome. It is an earlier event on my timeline, an event that is required for the latter event to occur. The fact that an earlier event is somehow responsible for the latter event does not indicate the nonexistence of the latter event. Ceci and Donna both wipe their noses because they sneezed. The special theory of relativity provides cogent reasons to think all times exist equally. All events are spread across spacetime. Later events are as real as earlier events.

## Becoming without transience

Fazekas (2016: 220) and Savitt (2009: 356; 2011: 564) agree with Gödel that there is no all-encompassing passage. Gödel however inferred that the lack of global passage implies the nonexistence or ideality of passage. It is still possible that even in the absence of global hypersurfaces, time passes locally. According to Savitt's theory, passage might exist along an observer's timelike worldline. Passage may be identified with local successive events. Savitt develops the notion of a local and specious present as an open set in the Alexandroff topology.[28] Transience is defined by a succession of local 'nows.' To be clear, this account does not claim that nowness is "a property that hops from event to event" (Savitt 2002: 164). Time does not flow in the sense that it changes its temporal location with respect to itself (Savitt 2020: 88).

Savitt (2009: 356) supposes that "our timelike curves occur in a temporally orientable manifold" in which future and past light cones differ. He admits that he does not know what grounds the temporal asymmetry (he speculates on fundamental laws of nature; another candidate is, of course, causation) but takes the directionality of the succession of events as given. Savitt refers to a testimony of "an eminent psychologist" that the specious, or perhaps more respectably, the psychological present, is estimated to last from half a second to three seconds.[29] For the sake of his argument, Savitt chooses one second of proper time as the lapse of the psychological present. He then proceeds to apply the Alexandroff topology for transience, and ultimately for local passage among timelike curves. Alexandroff present, or ALEX, is the intersection in which the future light cone of an earlier event meets with the past light cone of the later event. This is depicted in Figure 1.5.

The present is the finite interval from an earlier event to a later event along the curve. Passage is equated with a succession of these ALEX

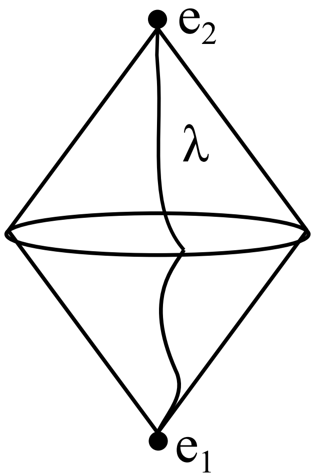


*Figure 1.5* The Alexandroff present. In Savitt's (2009: 357) own words: "ALEX ($e_1$, $e_2$) is the present for the interval from $e_1$ to $e_2$ along $\lambda$."

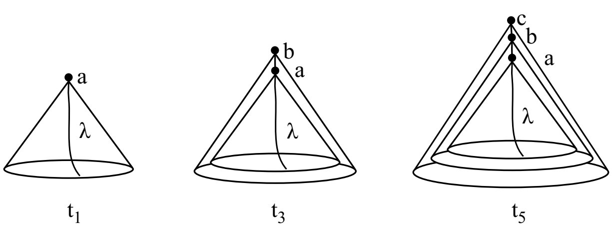


*Figure 1.6* B-coming from three different temporal perspectives. At $t_1$, all that lies on $\lambda$ is what has become at *a*. $t_3$ describes the situation from *b*'s point of view, the change in what has become at *b*. $t_5$ describes the situation from *c*'s point of view, the change in what has become at *c*.

presents. This notion of passage conforms to the causal structure of Minkowski spacetime: two events that are one second apart are all the events within ALEX that may be causally related (Fazekas 2016: 220).

Savitt went on to change the terminology at play. He prefers to call Alexandroff presents causal diamonds. The causal diamonds introduce a way to reconcile the manifest time (pre-1905) with the scientific time (post-1905). This is if we focus on the succession of events along timelike worldlines, not on global simultaneity slices. The successive causal diamonds denote regions of spacetime that mimic the way we might think of passage in the pre-relativistic sense, that is, a succession of present moments. The folk hardly conceive of time by contemplating on causal diamonds. Savitt's (2020: 94) objective is however to bring together the two pictures of time, the experiential and the spatiotemporal.[30] Although not even different human beings have the same worldlines, the local causal diamonds are tied to practically a common timelike curve that all inhabitants of the Earth share. If the causal diamond is one second of proper time in its temporal length, then it is approximately 300,000 kilometers wide at its waist.[31] This is over twenty times the diameter of the Earth. My friends and I practically inhabit the same causal diamond. The concept of a causal diamond may capture what is needed for a manifest present moment and the commonsensical notion of the passage of time in terms of 'nows' that come one after another.

Here I depart from Savitt's account. As I argued earlier, I think events are fundamental for relativistic account of the world. On this account passage is not about the transience of 'now.' Rather, passage is one event succeeding another event along an observer's timelike worldline. This is an entirely tenseless position. Lisa Leininger (2021) explains becoming without presentness by leaning on what she calls 'temporal B-coming.' Her overall theory, which is firmly based on special relativity and our basic understanding of the world in which time passes, defines becoming in a precise way: "an event *y* B-comes with respect to *x* iff ***Rxy***" (Leininger 2021: 136).[32] Becoming is a relation that holds among distinct events rather than among the 'now' and an event. Saying that an event becomes is deficient. Events must be related in order there to be becoming. Her theory of b-coming eschews the 'now', including the transcient 'now' as in the causal diamonds.

Leininger (2021: 142–3) draws multiple cones to illustrate her account of B-theoretic passage. Increasement exists in what events become from earlier to later. In her example, there are three cones that portray this increase along an observer *p*'s worldline λ. In her image, the cones are not stacked from one unit to the next. This would thicken the edges of the cones; this picture would not elaborate on the notion of change that is required for passage (an animation would do it). Instead of adjacent units, we may start with odd numbers greater than zero, $t_1$, $t_3$, $t_5$.

Leininger's explanation of passage is entirely tenseless. The passage of time, under her (2021: 143–4) theory, is the constant change in what has become at a given point from earlier to later along λ. The progression of change is established by the change in the later-than direction. This is fully consistent with the eternalist doctrine that maintains a closed future. There is becoming even though the future exists in one way for a specific observer. Events at *a*, *b*, and *c* are equally real. Events which have not become at *c* are causally inert with respect to it. Events that can become with respect to *c* must make some difference to *c*. What holds for *c* in this case is true regarding *a* and *b* as they both lie in the past worldline of *c* as the path *a*–*b*–*c* is along the common line λ.

I think Leininger's contribution tackles successfully an issue raised by Grünbaum, who thought that becoming is nothing more than just becoming aware of an event. This is not able criticism to Leininger's position. In her theory, the length of the worldline and the volume of the light-cones increase when new events b-come. I reckon both Grünbaum and Leininger agree that all events are spread out across spacetime, and that there is nothing metaphysically special about the present moment. Yet becoming is not merely about receiving novel information about some event. It is about the change from earlier to later along a worldline. This change is not articulated in terms of new events coming into being. B-theoretic eternalism maintains all events exist on a par. Change requires difference in what exists at different times (Leininger 2021: 134). As Arthur (1982: 102) observes, becoming does not require the moving present, as it might be construed "directly as a *relation among events*."

Leininger does not consider her theory to be deflationary. Passage is not mere temporal order: tenseless passage requires change in what has become. It should be emphasized that Leininger distinguishes between b-coming and passage. There can be b-coming without passage because passage requires a specific kind of change in the b-coming relation. There has to be something that changes regarding its b-coming relations. For time to pass, there must be temporally extended things. Leininger thinks the dynamic notion of change must be due to things having incompatible properties along the worldline. Thus, she puts it as follows:

> The only way in which there is a metaphysically significant account of temporal change is if there are temporally extended things. If the events consist of a thing along this particular worldline, then new events B-come for that thing. This means, of course, that the thing first lacks, and then possesses, a B-coming relation—just as an apple, for example, first lacks and then possesses the colour of redness. This is an incompatible state of affairs, and therefore suffices for temporal change.
>
> (Leininger 2021: 145)

Although my position concurs for the most part with Leininger's, I consider my theory as deflationary. In the next chapter, I argue that temporal extension—as opposed to spatial extension—is dynamic succession. Here I am using the term *temporal extension* differently from Leininger. She maintains that passage requires a change in an object's properties: The object must have incompatible properties at different times. This relates to the problem of persistence, a topic to be dealt with in the last chapter of this book. Temporal extension, defined as successive causal relation, is the basis for the positive argument for a relational passage of time. According to this view, passage is nothing over and above the succession of events, one thing coming after another. Causally related events are temporally arranged as they happen one after another along observers' worldlines. There is consequently no single passage of time but a multiplicity of passages. In the subsequent chapters, I consider various criticisms that relate to my argument.

## Notes

1 Gardner (1977) and Morganti (2015) provide overviews of the relationist doctrine.
2 It should be clarified that Arthur (2014: Chapter 7) eventually argues against the idealist reading of Leibniz on space and time.
3 Palmer (2020: Section 3) details the many interpretations of Parmenides and places them into a broader context of early Greek philosophy.
4 This is apparent in the famous Zeno's paradox (which is not a paradox, given our modern mathematical knowledge). We see Achilles reaching the tortoise. We see him reaching the tortoise, but the correct inference—for the Eleatics, at least—is that he may not cover the distance, because it would take an infinity of time. Therefore, motion is an illusion.
5 For a more thorough and nuanced analysis on the relation of Kant and Gödel, and on Gödel's idealist views on time, see Yourgrau (1991), Stein (1995), and Manchak (2016).
6 Broad (1938) and Smart (1949) advance a similar kind of criticism.
7 Callender (2016: 2.1) lists several proponents of the past hypothesis.
8 See Maudlin's interview by Ricardo Lopes in the *Dissenter*: https://www.youtube.com/watch?v=FnBC9JA9TVY. Date of consultation: October 14, 2021.
9 This is just a thought experiment based on a sketch. The violation of the CP-invariance, which is confirmed by an actual experiment, indicates that fundamental physical laws do require a temporal orientation (Maudlin 2007: 117–8).
10 I have argued that Hume subscribes to a thoroughly relationist ontology of time (Slavov 2021).
11 The Hume–Einstein connection has been perused by, for example, Stachel (2002), Norton (2010b) and Slavov (2016).
12 The scientism of Ladyman and Ross is positivist in spirit. They call their view NeoPositivist (Ladyman and Ross 2007: 303). They do not, however, subscribe to the principle of verification to separate meaningful and meaningless sentences.
13 I take that "the observable facts" here mean the concavity of the water in the bucket experiment and the tension of the chord in the revolving globes thought experiment.

14 For observability in science and ontological commitment, see Contessa (2006).

15 Do laws of physics permit any zones that are completely stagnant? Would light reach us from such a zone? Can light be stagnant? How about subatomic particles, fields, and forces? Shoemaker's thought experiment seems to pose many significant problems.

16 This is how Morganti (2016: 86) formulates the idea: "two events, or objects, or object-stages *a* and *b* are in a temporal relation by no means entails or presupposes that *a* and *b* differ with respect to their qualitative properties or their location in space." It is not clear to me what would be a concrete example of two merely numerically distinct events standing in a temporal relation without change.

17 This is a realist theory of the standard of synchronization. Clocks do not exist in isolation. They are part of a system that consists of a clock and a set of physical laws. A clock-law system represents time's passage correctly in case the measured durations by the clock conform to the laws of the system (Warmbrōd 2017: 3053). Much of the credence of this theory depends on what kind of metaphysics of laws one holds. In Warmbrōd's example, if the system's laws entail that cooking an omelet of three eggs takes three minutes, then an accurate clock measures three minutes from the beginning of the cooking to its end. If the clock reports a different time, the clock is inaccurate due to some bug in its machinery. Under such theory, the natural uniformity is founded on a law, which entails the outcome of such physical processes. This is clearly a non-Humean position: there are laws of nature that make things happen. The non-Humean view has been criticized, for example by Beebee, in that it is a metaphysically suspect view. For in addition to the physical objects of the world, like eggs, frying pan, and stove, there are laws. This means that there is a more fundamental level of reality than physical reality, that is, there is a reality of laws of nature. Yet this reality of laws itself is not physical, because these laws are external rulers of the physical world. It is not surprising that originally the notion of a law of nature had theological roots. For the origin of the concept of a law of nature, see Ott (2009).

18 If the pragmatic account of synchronization is correct, it is obvious why so many of our measures of time, including watches and calendars, are cyclical. For our everyday life, days, months, and seasons are practically important (sleep, fertility, acquiring of food, etc.). The measures of days, months, and years are all based on cyclical processes.

19 Eddington (1920: 46) and Weyl (1921: 116) disagree. The former claimed that events are static in nature: "Events do not happen; they are just there, and we come across them." The latter insisted that events are subjective phenomena: "The objective world simply is, it does not happen. Only to the gaze of my consciousness, crawling upward along the lifeline of my body, does a section of this world come to life as a fleeting image in space which continuously changes in time."

20 Gu (2021: 11236) notes that the synchronization parameter ε in $t_B = t_A + \varepsilon(t_{A'} - t_A)$ could be 0 so to render the speed of light infinite in one direction or 1 so to render it infinite in the opposite direction. This is perhaps a logical possibility. It is unclear whether light could physically behave in a way that its speed is infinite. Moreover, instantaneous light signals do not have a place in the whole edifice of contemporary physics.

21 Moving rapidly regarding the typical speeds we observe in our environment.

22 This is a summary from Philpapers section on eternalism: https://philpapers.org/browse/eternalism

23 He, of course, thinks that the roundtrip time is constant, so $c = 2\overline{AB} / t'_A - t_A$ is a fact based on experience (experiment; Einstein 1923: 40).

24 Balashov (2010: 56) maintains that "statements about simultaneity … are meaningless in relativistic spacetime." Yet on the same page, in the explanation of Figure 3.7, he writes that "Events $p$ and $q$ are simultaneous in coordinate system $(x,t)$: $t_p = t_q$ but not in $(x',t')$: $t'_p \neq t'_q$." There are meaningful ways to express relations among two events in a frame, even though the temporal order of spacelike separated events is not factual *simpliciter*.

25 I have argued for this point more thoroughly elsewhere, see Slavov (2022).

26 Pettini (2018: 1–2) explains that fundamental observers in cosmology are those who are comoving with the substratum, that is the idealized "cosmic fluid." We are not fundamental observers as we are in relative motions regarding a great many galaxies.

27 Here 'future' is connected to an observer's present by means of a worldline. There is no fixed temporal order outside of light cones. Bouton (2017: 108–13) criticizes the idea of the determinateness of the future.

28 The idea comes from Winnie (1977), who used the notion of the Alexandroff interval.

29 Savitt does not name his authority. Valtteri Arstila (2018) has argued that our temporal phenomenology does not contain a specious present. It is not needed to account for our phenomenology of time. Arstila refers to Vincent Di Lollo's (1980, Di Lollo and Wilson 1978) series of experimental studies. In one of the experiments, subjects were presented twenty-four flashing dots on a five-by-five matrix. One dot on the matrix is missing, and the subject's task is to figure out which. In another experiment the dots were shown in two separate flashes. Both flashes contained twelve dots. The leading and trailing displays were separated by varying times, ranging from 10 to 200 milliseconds. The task is not in itself that demanding. Cases in which the flashes of the leading display lasted 80 milliseconds or less, the subjects identified the missing dot almost flawlessly. The longer the leading display lasted, the worse for the subjects' ability to recognize the empty spot. When the leading display took over 120 milliseconds, more than 80 percent of the subjects misidentified the spot. Going over 160 milliseconds further decreased the correct identification (Arstila 2018: 292–3). Arstila holds this to constitute evidence against the specious present. There are two reasons for this:

> First, the trailing display was presented ten milliseconds after the leading display in all experimental conditions. Accordingly, if the doctrine is correct, the trailing display would change from occurring now to just-occurred and then to further past in the same way in all experimental conditions and the performance should remain the same throughout the experiment. This is not the case, however. Second, if the doctrine is correct—if there is a 'short duration of which we are immediately and incessantly sensible'—then the information about the leading display should not disappear at the moment when we first have experiences of the trailing display. After all, such disappearance means that the information about the leading display is not immediate and sensible anymore. Nevertheless, this is exactly what happened for longer leading displays (Arstila 2018: 293–4).

Instead of the extended present, Arstila favors a dynamic snapshot view. Dorato (2011) also criticizes the physical interpretation of ALEX.

30 "*Philosophy of time should aim at an integrated picture of the experiencing subject with its felt time in an experienced universe with its spatiotemporal structure*" (Savitt 2009: 351, emphasis added).
31 For discussion of this position, see Gibson and Pooley (2006: 166–7, 170–1). Gibson and Pooley call the "Alexandroff present"/"causal diamond" the "Stein present."
32 By referring to Stein (1968, 1991) and Bigaj (2008), Leininger (2021: 137) lists five criteria ***R*** must satisfy to account for objective becoming.

# Part II

# Answering objections

# 2 Relational passage is neither trivial nor question-begging

Oliver Pooley (2013a) criticizes the deflationary account. In his view, it does not take passage seriously. He equates a proper theory of passage with objective becoming. Cogent theories of passage must hold that the future approaches, turns into now, and then becomes ever-more past. Passage is a fact that obtains independently of us. Pooley maintains that the B-theory cannot accommodate this. In his definition of the theory, B-theorists hold that a complete account of temporal reality is composed of events and their temporal relations (Pooley 2013a: 324). That theory posits, at most, the temporal relation of precedence and temporal distance. Moreover, for the B-theorist, there is nothing metaphysically special about the present moment. Writing or reading these sentences 'now' reflects a spatiotemporal perspective; the 'now' is not a profound feature of reality.

Pooley, together with John Earman, treats the deflationary account as trivial. "If one wishes to label the successive occurrence of events 'temporal passage' then, yes, time passes," Pooley (2013a: 326) bestows. "The only sense of 'becoming' available," writes Earman (2008: 159) in characterizing Dorato's (2002, 2006a) deflationary account, "is a thin and yawn-inducing one: by definition, events occur/happen, and the successive occurring/happening of events is becoming." Pooley has a more specific complaint about deflationary theories. He thinks they might not explain something coming ever more past. Before responding to the criticism about triviality or begging the question, I wish to explore Pooley's conditional argument for the existence of passage a bit more carefully.

Pooley considers an A-theoretic view that nevertheless eschews a universal 'now.' To be clear, Pooley is a B-theorist who thinks time does not pass. For there to be passage of time, tensed notions are needed, but a robustly relativistic account should do away with an absolute present. In contrast to traditional A-theoretic presentism, Pooley notes that facts about the present are not true *simpliciter*. Typically, a presentist claims that only the present exists or that everything that exists, exists now

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(Crisp 2004: 18). Jonathan Tallant (2009: 407–8) clarifies the intuitive appeal of the presentist credo:

> What's interesting, though, is that the slogan, 'everything that exists, exists now', really doesn't suffice to fully capture those intuitions. What the slogan leaves out, but the presentist must defend in order to preserve our intuitions about time, is that although only the present exists, it is true that various entities *have* existed, and that various entities *will* exist. Thus, there *were* dinosaurs and there *will be* Mars outposts.

According to presentism, if there is an all-encompassing list of what exists, all items of that list exist now. Propositions concerning the past or the future are dependent on the present state of the world, which is all there is. There are many perspectives on different times. One of the many perspectives is our present perspective. We can say that time passes, as we have different, changing tensed perspectives. This is the case although there is nothing metaphysically special about our present. The 'now' counts 'now' relative to the tensed truths we started with. Other times are present in relation to their own set of tensed facts (Pooley 2013a: 334–5). The ontological status of tensed locations is relative. Still, these relative locations, and how they change, are essential for passage.

Pooley gives some leeway to the B-theoretic attempt. While the future does not gradually become less future, and the past eventually more past, some events occur earlier or later. In some sense, one could say that an event $x$ is farther within sequences of events. Pooley (2013a: 335) thinks this is changing the subject. Applying tenseless temporal concepts is ontologically no different from the application of their spatial counterparts of nearer and farther. As there is no dynamicity within spatial relations, the dynamic notion of passage may not be located within any successive relations. So,

> all this amounts to is that the event is located at an ever greater temporal distance from each time in the sequence. This no more corresponds to the real passage of time than the analogous spatial truth that, relative to a sequence of locations ordered continuously by their mutual spatial distances, the first element of the sequence is an ever greater spatial distance from each subsequent member of the sequence.
>
> (Pooley 2013a: 335)

I think this reasoning contains one questionable assumption. The hidden premise is the assimilation of two types of extension, spatial and temporal. Spatial extension is nothing dynamic. It may be formed by one object or a sequence of objects with spatial coordinates. Think the simple $x$-axis and several points along it. There is nothing changing among the points, no passage from one point to the other. The points have intervals, but space does not, so to speak, pass between the points.

Temporal extension is different from spatial extension. As Deng (2010: 743) has it, "[t]emporal extension, i.e. succession, is not spatial extension, but succession, after all." There is something dynamic about B-theoretic succession. There is an event, followed by another event. Some events occur earlier than others, and some later than others. Whether we treat events as point-like or physical does not matter here, as between the events there are intervals. Among various intervals, time passes locally. This is captured by the special relativistic concept of proper time, introduced by Minkowski in 1908. The lapse of time is frame-invariant. Before developing this point further, I wish to approach the issue from a more commonsensical point of view.

To explain the difference between duration and length, and why the former is dynamic in the way the latter is not, consider the following comparison. I start lecturing at quarter past noon. At quarter to one, I start drinking coffee. At quarter past one, I have finished the coffee. At quarter to two, I have finished lecturing.[1] The lecturing takes three times more time than the drinking of the coffee. The temporal length of the lecturing is three times longer than the length of the drinking of the coffee. The mundane explanation is that more time passes in lecturing than having coffee. Duration and passage are enmeshed. There are conceptual differences between them, but they may not be completely disentangled. Representing events and their durations with a simple one-dimensional spatial axis leaves something temporal out. It does not incorporate all the temporal reality of the situation. Spatial exposition of temporal intervals excludes passage. The same for simple algebraic analogies, like $3x > x$ in which $x = 30$ min. This is a description of the interrelationship among time-quantities. It does not include all temporal aspects of the scenario.

We experience things succeeding each other. The experience of succession is characterizable in terms of before and after. Deng (2019: 11) observes that our temporal phenomenology contains succession, order, and duration. We experience changes and are aware of a variety of persistences. In the succession of events, we do not perceive one thing as present and then perceive others as past or future. Passage does not require that the 'now' is special even phenomenologically. This is how Skow (2015: 203–4) puts it. Say you spend today and yesterday in a room that is painted completely red. All the walls, the floor, and the ceiling of the room are perfectly homogeneous. You sit in the room and just look at the walls. Let's assume we can perfectly describe our phenomenologies (suppose we have black belts in autophenomenology, as Skow has it). Does your experience distinguish between yesterday and today? How is the 'now' special in any way? "Presentness makes no difference to how things look or feel or sound," Deng (2019: 11) comments. The difference-maker is the succession of perceptions, of one thing coming after another. This comes quite close to what Hume thinks about time in the second part of the first book of his *Treatise*. Fazekas (2019) develops an account according to which the experience of passage is made of our experience of continuously moving to later times. We perceive constant change, both in our environment and in our selves. We do not have control over the advancement to later times or over the torrent of changes.

Note that this is again not changing the subject. The deflationary theories are realist theories. Temporal relations of earlier and later must hold objectively. They cannot vary from one individual's or community's experience to another. Our temporal experience fits with a B-theoretic metaphysical account that can incorporate a rigid relation of earlier and later, which relate two timelike connected causal events. This is consistent with a relativity-inspired metaphysics that treats time as the causal dimension of spacetime (Mellor 1998).

In this context, it is important to clarify the notion of 'objective.' It is notoriously difficult to pin down what objectivity amounts to. In the philosophy of science, this term is applied in various ways.[2] When it comes to the ontology of time, objectivity should be separated from substantivity. Pooley refers to Norton's (2010a: 24) characterization, according to which passage is "a fact about the way time truly is, objectively. The fact of passage obtains independently of us." This definition equates objective and substantial existence. I do not think the two are, at least necessarily, the same. Substantivalism about passage requires that there is time itself that flows at a steady pace. Relationism denies that there is a time itself. Instead, there are physical objects and events that are temporally related. Importantly, there is change among the objects and events. Relationism maintains that we have veridical beliefs about many temporal aspects of the world but not about the putative self-existing time.

In denying substantivalism, relationism does not lend support to idealism. Relationism as defended in this book is a version of realism. There is a clear difference in Kantianism about time. Kant heavily emphasized the human dependence on time (and space). Because of his transcendental idealism, Kant does not think that time is merely subjective, like a subjective idealist would. He grants that "the empirical reality of time, i.e., objective validity in regard to all objects that may ever be given to our senses" (KdRV A35/B52). In Kant time is an *a priori* form of intuition (*Anschauung*), which makes universal human experience of objects possible. He claims that "time is not something that would subsist for itself or attach to things as an objective determination, and thus remain if one abstracted from all subjective conditions of the intuition of them" (KdRV A32/B49). Kant concludes that "time is therefore merely a subjective condition of our (human) intuition" (KdRV A35/B51). Weinert (2005: 588) contends Kantianism can be updated to match relativity:

> many of Einstein's contemporaries concluded that time could not be part and parcel of the real world. Time passes at different rates for each observer, depending on the respective speeds of their reference frames. Time cannot be an objective property of the material universe. It seems to depend on the perception of observers.... The Special theory seemed to confirm what Kant had claimed: that time was a feature of the human mind.

In my view, time is "part and parcel of the real world." It is importantly "a feature of the human mind," but it is not only something that concerns mental beings. Relationism agrees with Kantianism in that time does not "subsist for itself." But relationism maintains that time does "attach to things as an objective determination." Consider the notion of an 'observer' in physics. This notion should not be equated with a mental being. Deciding which beings are mental is a huge topic of its own. If we do not take panpsychism as our starting point,[3] a great many nonmental beings count as observers, including, for example, the rest frames of measuring devices, macroscopic bodies, and elementary particles.

I think special relativistic considerations, unlike how Weinert thinks, point against the Kantian view. At the beginning of the 20th century, many neo-Kantians viewed Kant's philosophy of time very positively in the light of the development of the special theory of relativity (Ryckman 2018: Section 3.1). The discovery of muons by Andersen and Neddermeyer in 1936, and the corroboration of the muon theory by Street and Stevenson in 1937, renders the Kantian position hard to defend.[4] The muon example is just one corroboration, among others, of the special theory. As Max Born (1969: 109) noted in a lecture "Physics and Relativity" in the mid-1950s,

> [a]t present special relativity is taken for granted, the whole of atomic physics is so merged with it, so soaked in it, that it would be quite meaningless to pick out particular effects as confirmations of Einstein's theory.

I wish to refer to muons as I think they make a graphical example that weakens an anthropocentric philosophy of time. Muons are created when cosmic rays strike the upper atmosphere. They travel toward the ground and particle detectors register them. In a nonrelativistic world, muons would not be observed at the ground. In the ground frame, muons decay slower than in the muons' frame, and in the muons' frame, the distance between the atmosphere and the ground is shorter than in the ground frame. If time dilation/length contraction did not exist, only about

$1/10^{40}$ of the muons would be predicted to reach the Earth's ground, instead of 1/10 (Knight 2008: 1159).[5] If such relativistic phenomena did not occur, muons would not be detected at the ground. An inference to the best explanation is that the theory of special relativity is true:[6] clocks, which in this case are half-life decays, are subjected to the Lorentz transformations. Can the Kantian conception of time explain this? The fact that muons hit the ground and get detected does not simply refute the Kantian view. Yet it does undermine theories that treat time as a thoroughly human phenomenon. Time dilation is a real phenomenon in the material universe. It is not something imposed by conscious beings. There are intervals of time, and they are related. The way they are related is relevant to the existence of physical objects. Without time dilation (or length contraction), muons would not survive from the atmosphere to the ground as they do. There is something objective about temporal relations. This objectivity is not due to or limited to human intuition. Temporal features of the world exist in a way not captured by an anthropocentric account of time. According to relationism, as its name propounds, temporal reality is constituted by relations.

There are many aspects of time that could be thought to be objective or subjective. For this book, the main interest is the objectivity of passage. To consider the objectivity of relational passage, we may start with the order of events. Spacelike events are in each other's absolute elsewhere, and so not connected in any way. Their temporal order is relative, not objective. For their part, the order of timelike-related events is objective. By this I mean that all possible observers agree on their temporal order. There is no definite number of frames of reference, but all frames reach an unmistakable conclusion about the definite order of timelike-related events. For example, the four following events are objectively related. The First World War partly caused the Second World War. My parents were born not too much after World War II; they were certainly affected by it. I was born after my parents as they caused me. I might be younger or older than my parents, but my birth unequivocally succeeds their births. There is an explicit direction: WW1 > WW2 > the birth of my parents > my birth. One does not need to assume absolute time or a privileged frame to establish this conclusion. There are as many times as there are frames, but in no frame will the order of WW1 < WW2 < the birth of my parents < my birth take place.

Now to get back to the notion of lapse of time. Consider Gödel (1949: 557–8) on this matter:

> Change becomes possible only through the lapse of time. The existence of an objective lapse of time, however, means (or at least is equivalent to the fact) that reality consists in an infinity of layers of "now" which come into existence successively. But, if simultaneity is something relative in the sense just explained, reality cannot be split

> up into such layers in an objectively determined way. Each observer has his own set of "nows", and none of these various systems of layers can claim the prerogative of representing the objective lapse of time.

There are many relevant aspects in this condensed and convoluted quote. The first sentence reads: "Change becomes possible only through the lapse of time." This should somehow imply "the fact that reality consists of an infinity of" 'now'-slices. This sentence is a part of a larger claim about the unreality or ideality of change, and hence the unreality or ideality of passage. The first thing to note is the supposed problem about the existence of the lapse of time. Think again about the case of lecturing and having coffee. This is a duration: there is a temporal interval between starting and finishing the lecture. It also contains the shorter interval of drinking the coffee. It is unquestionable that this lapse of time involves change. I start lecturing. While I speak, all sorts of things are changing in my mind, in my body, and in the lecture room. Then I proceed to drink the coffee. Time goes on, and little by little the cup empties. All the while the lecture continues and comes to an end. By admitting that change is possible within a time span, one is not committed to the view that passage is about adding up simultaneity slices. One can argue for a local becoming along a worldline by considering the concept of proper time that tracks the lapse of time.

Arthur (2010, 2019) clarifies what he takes to be Gödel's mistake. In relativity, there are two concepts of time: The coordinate time function $t$, and the proper time $\tau$. The former is relative. "It is only the latter concept," Arthur elucidates (2019: 110), "that is associated with the temporal becoming of events in succession, and therefore represents the time elapsed for such a process." Coordinate time is among the spatial coordinates $(x, y, z)$ of an inertial frame. A set of coordinates $(x, y, z, t)$ assigned to an event in a coordinate system is related to another one via the Lorentz transformations. In analyzing Gödel's position, Arthur (2006: 138) notes that "if time lapse is to be counted as objective, it must be invariant under change of inertial frame." Arthur endorses the frame invariance of time lapse, specifically the invariance of proper time. This is because the quantity of elapsed time is measured by proper time $\tau$, which is computed by taking the integral along a worldline of the measured time of $\tau = \int d\tau$, in which $d\tau = \sqrt{\left(c^2dt^2 - dx^2 - dy^2 - dz^2\right)}/c$. "The proper time so calculated," Arthur (2006: 141) explains, "is invariant to change of frame: it will come out the same no matter what inertial frame (with co-ordinate values $x$, $y$, $z$ and $t$) is chosen."

Time lapse as measured by proper time is relative to the path in spacetime, not to the frame of reference adopted to calculate it. The coordinate time and the proper time may be numerically identical (this is the case of the first trajectory in Figure 2.1). A non-accelerating observer has speed

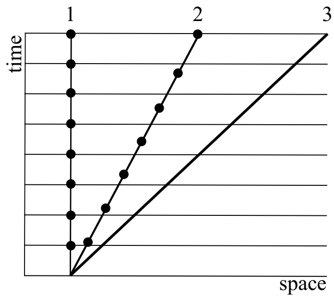


*Figure 2.1* Three spacetime trajectories. I have drawn this diagram based on Holster (2021).

$v = 0$. In that case $\gamma = \left(1-\beta^2\right)^{-1/2} = 1$ so the proper time and the coordinate time are the same number. This identity implies that the longest temporal interval among two spacetime points is the straight line that connects those points. Every other path through spacetime is curved and shorter in time. Interestingly, even special relativity is equipped to deal with such non-inertial paths (Arthur 2019: 131). The proper time, taken as an integral along the worldline of an observer, will be different for the different observers. Observers age differently as they take different paths through spacetime.[7] Accordingly, time dilation is a very real phenomenon.

The concept of proper time is important for B-theoretic becoming. Processes occur along the timelike worldline, along the line whose intervals are the measures of proper time. This can be illustrated with the aid of the special relativistic metric equation, $c^2\Delta\tau^2 = c^2\Delta t^2 - \Delta r^2$, which clarifies the relation between proper and coordinate time (Holster 2021). $\Delta\tau$ is the proper time elapsed between two points on the trajectory, and $\Delta t$ is the coordinate time between two points. $\Delta r$ denotes the spatial interval. In Figure 2.1, three trajectories are depicted. The first on the left is an observer at rest. The second in the middle traverses with half the speed of light. The third on the right is a photon's trajectory.

In the case of the first trajectory, the observer does not move along any spatial dimensions, as $r_1 = 0$. Hence, $\Delta\tau_1 = \Delta t_1$. In the case of the second trajectory, its velocity is $v_2 = \Delta r_2/\Delta t_2$. As $v_2$ in the example equals $c/2$, $\Delta r_2 = 1/2c\Delta t_2$. $\Delta\tau_2$ is hence $\sqrt{3/4}\Delta t_2 \approx 0.87\Delta t_2$. In the case of the third trajectory, the photon moves at $v_3 = c$, which yields $\Delta\tau_3 = 0$. For the photon, nothing ever comes to be: time does not pass for a light particle.

The result of the second trajectory corresponds to the time dilation equation, according to which $\Delta\tau_2 = \sqrt{1-\left(\frac{0.5c}{c}\right)^2}\Delta t_2 = \sqrt{3/4}\Delta t_2 \approx 0.87\Delta t_2$.

According to some expositions (like Balashov 2010: 62), the proper time is measured in the inertial frame in which the events occur at the same place. A clock at rest in this frame is thought to measure the proper time intervals among spacetime points. The problem with this approach is how to apply proper time to curved paths in spacetime (Arthur 2019: 131). Based on Maudlin's (2012: 76) analogy, we may say that clocks are like odometers in cars. Say two observers have identical clocks that are in synchrony. Then they traverse different paths through spacetime. At the rendezvous they note that their clocks do not match as different amount of time has passed between the two. The same is true with car mileages. Say two cars have the same odometer readings. They drive different paths and then come back together. After the travel, the readings do not match.

All of this is consistent with the eternalist credo. Proper time is about timelike paths. The order of spacelike separated events is relative. Say that in one frame the time interval between two distant events is zero, then in (almost all) other frames, it is not zero. This is how Gödel (1949: 557) formulates the same idea:

> The very starting point of special relativity theory consists in the discovery of a new and very astonishing property of time, namely the relativity of simultaneity, which to a large extent implies that of succession. The assertion that the events *A* and *B* are simultaneous (and, for a large class of pairs of events, also the assertion that *A* happened before *B*) loses its objective meaning, in so far as another observer, with the same claim to correctness, can assert that *A* and *B* are not simultaneous (or that *B* happened before *A*).

As the order of spacelike separated events is relative, there is no absolute present moment. Past, present, and future all exist. If all temporal locations exist equally, different times do not change. My position is akin to Gödel's in this regard. Yet this brief sojourn with eternalism does not refute the existence of change or lapse of time. Special relativity can accommodate the reality of becoming. Arthur thinks Gödel's mistake was to equate proper time with the coordinate time as measured in the observer's rest frame. He (Arthur 2019: 129) contrasts his view with Gödel provocatively:

> time lapse (in the sense of how long a given process takes, how quickly it becomes) is not measured by the time co-ordinate function. So Gödel's "unequivocal proof" of the ideality of time falls flat on its face.

If one equates the measurement of length and the measurement of duration in an observer's rest frame, it is difficult to find any room for passage.

Say the lecture room is 10 meters wide and the lecture lasts 90 minutes. The measurement of length is done by a yardstick, and the measurement of duration is done by a clock. In this case, the measurement of duration does not reveal anything dynamic about the interval in question in the same way as the measurement of length does not reveal anything dynamic about the interval in question. The measurement of proper time is the interval on the path the observer takes in spacetime. It is along their worldline in which things come to be, in which processes occur successively. There we find the passage of time.

Note that it is possible to make sense of the passage of time without units. When comparing two paths, the first with velocity $v_1 = 0$ and the second with velocity $v_2 = 1/2c$, we may say that time passes more quickly for the first observer *in comparison* to the second and that time passes more slowly for the second observer *in comparison* to the first. With those values, about 115 precent of time passes for the first observer *in comparison* to the second observer, and about 87 percent of time passes for the second observer *in comparison* to the first. Likewise, we could say that person number one, who is 1.9 meters tall, is about 115 percent of the height of person number two, who is 1.65 meters tall, and person number two is about 87 percent of the height of the first person. We do not need units for such comparisons. Importantly for a relationist ontology of time, the passage of time is made meaningful by a comparison between observers. The rate of passage of time is not compared to any putative time itself, but the comparison is made between different observers in spacetime. No need to assume a substantial time that flows at one given speed no matter what.

Relational passage is a realist theory that takes the relative nature of time very seriously. There is no unique time but many times. Fazekas (2016) shows how multiple B-series coexist. This is based on the idea that only the relations between timelike separated events "really occur successively" (Fazekas 2016: 216). This does not indicate that there is only one universal direction of time. I shall get back to this point in the next chapter that analyzes the direction of time. Here it suffices to say that there is no one passage of time but multiple passages of time. Timelike events occur successively in an objective way. Different observers reach the same unambiguous conclusion about the time order of events if they are timelike connected.

Consider a commonsensical case of the passage of time. An avid sports fan has eagerly followed all the Olympic Games of the 21st century. They have seen Sydney, Salt Lake City, Athens, Turin, Beijing, Vancouver, London, Sochi, Rio de Janeiro, Pyeongchang, and can't wait for the deferred Tokyo Games. The temporal order of the Games is unambiguous. No one questions their successiveness. The definite direction and succession of these events is the basis of passage. Time passes from earlier

Olympic events to later. I, for one, happen to be very interested in the upcoming Tokyo Olympics. I have a sense of moving toward the Games, which is in my future (I am writing these sentences in mid-February 2021). I also feel passivity regarding the passage of time; it is as if I am being taken to a later time, the time when the Games commence.

We are passive with respect to moving from earlier times to later times but active with respect to moving in different spatial directions (where being active is restricted by our physical abilities). It is logically possible to travel back in time, and in this sense, spatial and temporal dimensions are alike.[8] We are nevertheless passive subjects when it comes to the passage of time. This is how the B-theoretic, metaphysical theory accounts for our temporal experience. Human actions and decisions have consequences. Making a decision or initiating an action has immediate effects in the time they are carried out, and less forceful effects at farther times. If we could trace the last effect to its first cause, "the resulting sequence of events would be one whose elements exhibited monotonically increasing temporal coordinates," Deng (2013: 718) notes. The spatial coordinates of the sequence of events do not exhibit anything increasing monotonically. "That," Deng (2013: 718) concludes,

> very simply, is why we can do nothing to 'halt the passage of time', or to 'influence its speed or direction', i.e. why we feel we are being 'taken to' ever later times, independently of our own will. The reason is that what we can do is itself part of the causal order of events, and that order is also their temporal order. Our situation is different with respect to space: many of our actions bring it about that we move in space in a particular direction or that we stay in the same place. That is why we do not have the same sense of passivity with respect to space.

When subjects are placed within the causal history of the world, it seems obvious that the temporal order they register and the passage they experience are not merely subjective reactions. The causal history of an observer can be presented with a worldline in standard relativistic diagrams. Spacelike events fall outside the cones, and so spacelike separation does not exhibit a genuinely temporal order. Fazekas (2016: 222–3) explains how passage requires change. The earlier stages of local parts of the universe somehow bring about its later local stages. When it comes to distant events in space, not connected by any signals, there could not even be any passage among those events.[9] The one event does not affect the other in any way. Within timelike-related stages of the universe, change occurs between events and objects. One event can cause another event: hitting a tennis ball causes it to change its motion. Changes like these are not merely subjective perceptions but active processes that occur constantly in us, in the reality around us, and in the interaction between us and our surroundings.

The purpose of this chapter was to show that the theory of relational passage is a proper account of passage. It is far from trivial. According to relationism, passage is real, local, and objective. This is different from substantial and global passage. As I have argued, however, the rejection of self-existing universal flow does not imply subjectivism or idealism about passage. In explicating my position, I relied on causation in many instances. I elaborate on the role of causation and its relation to direction and passage in the next chapter.

## Notes

1 I have used this example previously in a footnote (Slavov 2020c: fn. 4). It borrows from MacDonald (2012).

2 For a recent overview of the concept of objectivity in the philosophy of science, see Koskinen (2020: Section 2).

3 This book assumes a nonreductive formulation of physicalism. For a defense of panpsychism, see Goff (2019).

4 The historical term for muon is "mesotron."

5 For a very clear exposition of how the detection of muons is possible, see this *Aeon* video: https://aeon.co/videos/extremely-small-and-incredibly-fast-muons-offer-amazing-proof-of-special-relativity

6 One might object that an inference like this is not necessarily an inference to the right explanation because empirically equivalent alternative theories may be devised. It is true that in history there have been relevant rival theories. Lorentz's ether theory was partly empirically equivalent with Einstein's. It was not however completely empirically equivalent as the former did not fit with quantum physics and general relativity (Acuña 2014: Section 5). Today, Einsteinian special relativity is supported by a vast amount evidence, and it is in accordance with the consensus of the institutionalized international physics community.

7 For an explanation and calculations, see Maudlin (2012: 77–9) and Newman (2021: Section 2).

8 To properly assess the disanalogy between space and time, one needs to consider causation. Deng (2013: 718) stresses the "fact that in a causally ordered sequence, the temporal coordinate of elements monotonically increases is significant; it reflects the fact that the temporal dimension of space-time is the causal dimension."

9 This modal claim is premised on the light postulate.

# 3 Passage is directed

If passage is real in the relational sense, then it is directed. There is passing from earlier times toward later times. This does not entail a single, preferred direction. In accordance with relationism, there are passages of time, so there is a plurality of directions. The theory that I defend in this chapter is that there are many timelike-related causal sequences of events. Within these sequences, there is a definite directional passage. Yet no direction is truer than any other. No passage is grounded in putative substantive and unique flow.

The direction of time is a commonsensical idea,[1] but it has been challenged on many grounds. A typical counterargument to direction is the time-reversal invariance of physical laws. David Albert refers to Newtonian mechanics to explain the symmetricity of laws of nature. In his view, Newtonian mechanics is completely mute on the direction of time. Particles change their positions with respect to time (and space), but they do so without a definite temporal (and spatial) direction. In Albert's (2003: 6–8) example, imagine watching a film in which a baseball is thrown directly upward. We see the ball going up, and after reaching its apex, it falls. Say we watch the film again. We see the ball going up. When it reaches the apex, we stop the film. Then we watch it in reverse. What we see now is the same downward motion as in the first time we watched the film. In both cases, when the ball falls, what we perceive is the acceleration toward the ground.

In essence, Newtonian dynamics describes how bodies accelerate due to impressed forces. "The apparent acceleration of any particular particle," Albert (2003: 6–7) claims, "at any particular frame of the film run forward will be *identical*, *both* in magnitude *and* in direction, to the apparent acceleration of that particle at that frame of the film run in reverse." Newtonian dynamics is not, by far, the ultimate theory of the physical universe. One could still argue that, much like the rest of physics, it is time-symmetric. The second law of thermodynamics and the violation of CP invariance might introduce an exception, but typically laws of nature lack any reference to the direction of time.

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In general terms, happening backward is no different from happening forward. Say that the all-encompassing and ultimate theory of the physical world is *T*. "Then," Albert (2003: 11) has it, "any physical process is necessarily just some infinite sequence of $S_i \ldots S_f$ of instantaneous *states* of *T*." Reversing the order of events is just the occurring of the sequence $S_f \ldots S_i$. Furthermore, the direction of time does not depend on our knowledge of what moment counts as 'now.' We may conventionally choose some time, like noon, and then calculate how the particles have evolved at 10 a.m. or 2 p.m. All this requires is the computation of the velocities and positions of particles at different times. What is 'now' and what those different times are is insignificant for the direction of time (Albert 2003: 5–6).

Unlike how Albert thinks, there are cases of Newtonian mechanics in which one can infer the beginning of the cause of motion. These inferences do not require one to pass the bounds of Newtonian dynamics. Bernard McBreen (2018: 15) shows there is a fundamental problem in Albert's argument. Albert does not consider the initial throwing of the ball. This is the beginning of the causal process. In McBreen's argument, which I have previously modified a little (Slavov 2020c: 34), we may imagine a scenario in which a toy cannon shoots a ball upward at a slight angle. The ball will fall and then bounce on a concrete surface a number of times before coming to a halt. If we have recorded the process and then run the film backward, we will very easily decide the direction of time. The ball does not spontaneously jump off the concrete. The machine that gave the initial thrust to the ball is the beginning of the causal process. The ball will eventually stop because of friction and air resistance. Friction and air resistance are the end of the causal process, not its beginning. They do not cause the initial change of motion. That is caused by the application of a force by the machine. All of this is perfectly consistent with Newtonian physics. Running the film in two directions shows two different starts of motion. The application of force by the cannon is possible in the Newtonian system, while a spontaneous jump without the exertion of force is impossible in that system. The two distinct modal cases enable us to judge the direction of time correctly.

McBreen (2018: 15–6) has another cogent criticism of Albert's argument for the time-reversal invariance of Newtonian dynamics. Say a meteorite travels from outer space to our planet Earth. We can easily imagine the process in reverse. In the inverted case, the decreasing velocity of the object would be due to Earth's gravitational field as well as the atmosphere drag. But what is the initial cause in that scenario? There should be something peculiar, like launching it from a spacecraft. In the original scenario, the cause of the process is identifiable, whereas it would not be so if we change the direction of time. Rocks do not regularly escape Earth's gravitational field.

To provide an argument in which the causal order grounds the temporal order, I assume the Humean framework. I do not wish to subscribe to a reductivist view that reduces causal notions to constant conjunction. In fact, I wish to be as neutral as possible on the overall theory of causation as this book is not a book about the philosophy of causation. What is relevant is the temporal asymmetry of causation. The starting point is that the causal relation is a successive relation. This means that the cause begins before its effect. To that end, it is important to take a closer look at Hume's argument for the temporal priority of causes to their effects in his *Treatise*.

Hume advances his argument in one paragraph (T 1.3.2.7; SBN 75–6). This is accompanied by one of his definitions of causation. According to the definition, a cause is an object preceding another object, and the following object is the effect (T 1.3.14.31; SBN 169–170). He also thinks temporal asymmetry should be a rule for recognizing causal relations. In the section "Rules by Which to Judge of Causes and Effects," Hume establishes in total eight rules for causal reasoning. The purpose of this collection is to differentiate mere regularity from causal relations. The second rule of the list states: "The cause must be prior to the effect" (T 1.3.15.4; SBN 173). In this quote, 'must' does not denote necessity. Hume intends succession to be a regulative principle. It should help us identify causal relations and separate them from mere accidentally true regularities.

Hume allows that a cause might be partly, but not entirely, contemporaneous with its effect. He expresses his point in a long and somewhat rambling paragraph (T 1.3.2.7; SBN 75–6), in which he claims that a "sole" or "proper cause" cannot "be perfectly co-temporary with its effect." Dan Hausman (1998: 37) clarifies: "one should take Hume's temporal priority condition to require only that a cause *begin* before its effects begin." A striking example of this is when the Sun melts a pile of snow on Earth. The sunshine and the melting occur partly simultaneously, but the causally relevant action in the Sun, sole or proper cause in Hume's terminology, happens before the effected transformation on Earth. The energy required for melting is transmitted unidirectionally from the Sun to the pile. An easy calculation shows the priority of the proper cause and the posteriority of its effect. Say the nuclear reactions (the proper cause) in the Sun take place at time $t_S$. The snow melts (the effect) on Earth at time $t_E$, which is $t_S + x/c$, in which $x$ denotes the distance between the Sun and the Earth. $x/c$ is roughly eight minutes, so $t_S$ takes place eight minutes before $t_E$, and $t_E$ eight minutes after $t_S$.[2] In other words, $t_S$ happens before $t_E$, and $t_E$ happens after $t_S$. Just like Hume thought, the cause begins before the effect.

One thing remains unclear. Why causality and time are parallel in direction? Perhaps Hume failed to explain why the causal and temporal arrows align.[3] This is pointed out by Huw Price and Brad Weslake in

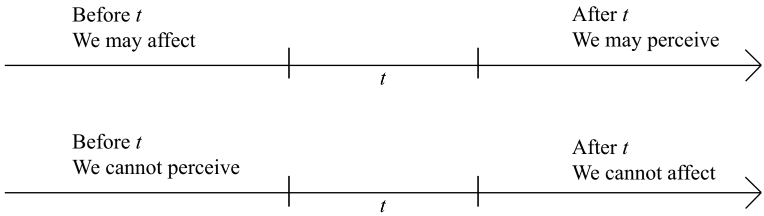


*Figure 3.1* Temporal asymmetry between affecting and perceiving. We can affect things before they occur and perceive them after they happen. We cannot perceive things before they happen or affect them after they have occurred.

their article "The Time-Asymmetry of Causation." They call his view "semantic conventionalism." By this Price and Weslake (2009: 414) mean the following:

> Hume takes the core of the causal relation to be the symmetric notions of contiguity and regularity, and proposes that we impose an asymmetry upon these symmetric relations, by labelling as 'cause' and 'effect' the earlier and later of a pair of appropriately related events. If Hume is right, then the relation between the causal arrow and the temporal arrow is merely a matter of *semantic convention*.

We could simply, as Hume partly did, define cause to be earlier than its effect. In Hugh Mellor's theory, the causal arrow is the basis for the temporal one. There is a fundamental asymmetry between our abilities to perceive and affect something. We perceive the past but cannot affect it. We may affect the future but not perceive it.[4] In B-terms, we see and hear what happens after a time *t*, but we may not see or hear what happens before a time *t*. Conversely for our actions: we may affect events that happen before *t*, but not what happens after *t*. In general terms, human actions and inactions are potentially efficacious because causes precede their effects. Likewise, sensory perceptions are effects of some physical causes as the effects are posterior to their causes (Mellor 1998: 105).

Temporal direction in causation is different from spatial directions. As Newton's second law is temporally symmetric, consider the ways in which spatial and temporal dimensions differ in the case of force causing acceleration. The change of motion takes place in the exact same direction as the impressed net force. Yet one might manipulate an object from different spatial positions. There is nothing special about striking a tennis ball from the forehand rather than the backhand side. The ball can move to any direction along the spatial axes $x$, $y$, and $z$. But there is a temporal asymmetry between hitting and accelerating. The application of force and the produced acceleration are simultaneous, but the cause of the change of motion—the movement of the racquet and the rest of the player's body—begins before the effected event. The ball then flies in the direction it is hit, with air resistance changing its motion considerably. The process is not temporally symmetric: the trajectory of the ball does not cause the player to prepare and hit the ball. The preparation occurs before the strike. Spatial and temporal dimensions are different in this scenario. Actions and their consequences have a multiplicity of spatial orientations but only one temporal direction.

Mellor (1998: 107) claims that "causes both *explain* their effects and provide *means* of bringing them about." Effects neither explain their causes nor provide means of bringing them about. Mellor tells a story about Jim winning a race. He won the race because he was the fittest contester. "Yet clearly the converse," Mellor (*ibid.*) points out, "is not true: Jim's winning the race neither explains nor is a means to his earlier fitness." Jim wins because he got fit at a time earlier than the race. In cases like these, we always find that causes are before their effects.

Mellor maintains causes should raise the probabilities of their effects. When Jim gets fitter, his chances of winning the race increase. If he is less fit, his chances diminish. Interestingly, this is what Hume says in his rules for causation (rule seven): "When any object encreases or diminishes with the encrease or diminution of its cause, 'tis to be regarded as a compounded effect, deriv'd from the union of the several different effects, which arise from the several different parts of the cause" (T 1.3.15.9; SBN 174). In explicating this rule, Hume invokes the relation between heat and pleasure. A moderate heat is the cause of a pleasant mental state. If the heat is diminished, it also diminishes the pleasure. If one augments the heat too much, this will result in pain. The heat is the cause of the effect of pleasure on the condition that this causal relation holds to some degree. For there to be a causal relation, a cause does not have to produce an effect *simpliciter*.

The strength of Hume's account is that it articulates how a cause begins before its effect even though there is partial overlap, as in the case of Newton's second law. The strength of Mellor's account is that it fits with relativity.[5] Spacelike separated events cannot be causally connected. If the events were connected by something faster than an electromagnetic signal, some frame could judge that there is backward causation among events. In the case of timelike separated events, the causal order is unambiguous. The causal order of events fixes their temporal order. The fact that the Sun melts snow on Earth is a causally ordered fact. It is not based on a semantic convention. We may not make a convention according to which a pile of snow on Earth causes the Sun to shine. To paraphrase Mellor, time is the causal dimension of spacetime.

Not all are convinced that causation is a properly successive relation. Michael Huemer and Ben Kovitz (2003) maintain that all causes are concurrent with their effects. In their view, both everyday examples and laws of physics evidence their co-temporality. According to the simultaneous theory of causation, "temporally extended action *e* occurs simultaneously with temporally extended cause *c*." This is a direct and deliberate contrast to the Humean sequential theory, which holds that "events of type *c* are followed by events of type *e*" (Huemer and Kovitz 2003: 556). They (Huemer and Kovitz 2003: 557) take the following cases to support their general position:

1. A lead ball is resting on a cushion; the presence of the ball causes an indentation in the cushion.
2. A locomotive is pulling a truck; the movement of the engine is responsible for the movement of the truck.
3. An iron bar is glowing because of its high temperature.
4. The lowering of one end of a seesaw causes the other end to go up.
5. Moving one end of a pencil causes the other end to move.

Huemer and Kovitz (2003: 558) mention the restriction imposed by special relativity: there is no instantaneous distant action. Causal action might be transmitted only at or slower than the speed of electromagnetic signals. Then they go on to analyze the concept of force in classical physics. Newtonian dynamics and electromagnetism hold that force and acceleration are simultaneous and continuous. Newton's second law implies that the exertion of force and the produced acceleration occur simultaneously. Likewise, charges accelerate due to electric and magnetic fields instantly. This holds

> for all the equations of classical physics: one never posits a force, acceleration or other effect resulting *after* some causally relevant factor exists. Rather, these equations posit forces determined by the present configuration and properties of physical objects. The configurations of physical objects are, in turn, continuously changing at a rate determined by those forces.
>
> (Huemer and Kovitz 2003: 559)

The theory of simultaneous causation is meant to supersede its Humean rival. It does correctly indicate that the cause and its effect temporally overlap. It does however nothing to refute the point that the cause begins before its effect. We may analyze the famous billiard-ball example. The eight ball and the cue ball rest on a pool table. Both balls are motionless. There is no collision if the cue ball is not first struck toward the eight ball. Newtonian forces are actions that commence before touch. Here it is appropriate to cite Newton himself: "Impressed force is the action exerted on a body.... This force consists solely in the action and does not remain in a body after the action has ceased" (*Principia*, first Book, Definition 4). The force is the action located in the motion of the player's body and the cue stick. There is partial overlap and continuity among the cue stick and the cue ball, and eventually between the cue ball and the eight ball. The original cause of the whole process precedes the effected motion, and the effected motion comes after the original cause.

This is how Huemer and Kovitz (2003: 559) explain the reciprocal action of two colliding balls:

> As the force acting on either body increases and decreases, the body's acceleration changes simultaneously. There is no time delay between one body's pressing against the other and the latter's undergoing the resulting acceleration and compression. The forces change continuously because the relative positions and velocities of the particles in the two bodies are changing continuously, and those changes are caused by the forces being exerted, which are themselves just a way of describing the influence of the bodies on each other by virtue of their relative velocities and positions.

This account omits the fact that without an initial application of force, there would be no change of motion. Without the application of force, which requires that the action starts before the effect, the system of the two balls does not change in any way. Temporal succession is required for making a difference to the system. The same goes for Huemer's and Kovitz's other examples. The indentation appears after the heavy ball is put on the cushion; the locomotive pulls the truck after the engine has been started; the bar glows after it has been heated; the other end of the seesaw goes from low to high after it has been pressed on the other end; the pencil draws on paper after the other end is moved.

Huemer and Kovitz (2003: 557–8) acknowledge this kind of criticism. They focus on "causal relations in physics," which they take to instantiate simultaneity. At the level of laws, cause and effect are coincident. I agree that Newton's second law is a causal law, but as I have argued, it can be interpreted in a temporally asymmetric way. Newton's third law and conservation laws are different. Newton's third is rather a law of coexistence (Tooley 2004: 88). We may explain different equilibrium states with this principle. Two books that lean on each other both exert equal and opposite forces. Still the net force of the system is zero.

The equilibrium of two leaning books is a fringe case of causation. The two books impress each other, so they could be said to cause something in each other, although no acceleration occurs. If we apply conservation laws, they however do not instantiate causation at all. Take the collision of billiard balls again. The two-ball system has a definite total momentum, which is the sum of the cue ball's momentum and that of the eight ball. The initial momentum of the system is equal to the final momentum, that is, $\vec{P}_i = \vec{P}_f$ . The sum of the product of the mass and velocity of the objects within the system is invariant regarding time. This quantity,

$\vec{P}_{\text{total}} = \left(m_{\text{cueball}}\vec{v}_{\text{cueball}}\right) + \left(m_{\text{eightball}}\vec{v}_{\text{eightball}}\right)$, is conserved. The momentum of the cue ball is not somehow "transferred" to the eight ball. $\vec{P}_{\text{cueball}}$ is not a cause of any kind, and $\vec{P}_{\text{eightball}}$ is not an effect of any kind. The cause is the action performed by the player and the cue stick on the cue ball before the two balls collide.

This is analogous to the conservation of energy. Say we come to a "physically ideal" playground and find a seesaw in constant motion. The first end goes up while the second goes down, and then symmetrically, the first end goes down and the second up. There is nothing distinctly causal about this scenario. When the first end is up, its potential energy is maximal, and its kinetic energy is zero. The converse is true for the second end. We may draw energy charts for both ends and see how kinetic and potential energies instantaneously and continuously change. This is perfectly simultaneous because there is no causal involvement. If someone grabs one end and changes the total amount of energy of the seesaw system, then there will be some change in its motion. This happens on the condition that before the change of motion, an agent initiates the force, and only after that does the system change in some way. Conservation laws applied to isolated systems do not involve the kind of difference-making or counterfactual dependencies that causal influence requires (Blanchard 2016: 259).

Anti-causal philosophy of physics poses a challenge of interpreting any laws in causal terms. The anti-causal stance is typically personified by Bertrand Russell. In his classical article from 1912–3, "On the Notion of Cause," he contended that advanced science does not search for causes, because they do not exist. It would be a mistake to say that Russell was the first to articulate an anti-causal philosophy of science. In his 1721 essay "De Motu," George Berkeley argued that the business of physics (or natural philosophy more broadly) is not the discovery of causes, like the force of gravity. When causes and forces are not equated, we may avoid many difficulties associated with gravity. The universal force has inexplicable features, like the instantaneous non-mediated action at a distance. This was utterly unintelligible in the contemporaneous mechanistic paradigm. Universal gravitation should not be interpreted in causal terms, but causes should be limited to theology and metaphysics. In the mid-19th century, August Comte went on and developed his account of the three stages of human development. The highest positivist stage is free from causality. This is preceded by the metaphysical stage that leans on causation. This is, in turn, preceded by the theological stage that resorts to anthropomorphic projection. When physicist claims that 'force causes acceleration,' this is akin to folklore ways of explaining the behavior of inanimate nature in terms of the actions of living, humanlike beings. 'The thunder strikes' or 'the wind blows' refer to some agent in the same way as the production of force, and thus acceleration, requires some agent.

Like Comte, Russell maintains causal science is primitive. He uses Newton's law of universal gravitation to

> illustrate what occurs in any advanced science. In the motions of mutually gravitating bodies, there is nothing that can be called a cause, and nothing that can be called an effect; there is merely a formula. Certain differential equations can be found, which hold at every instant for every particle of the system, and which, given the configuration and velocities at one instant, or the configurations at two instants, render the configuration at any other earlier or later instant theoretically calculable. That is to say, the configuration at any instant is a function of that instant and the configurations at two given instants. This statement holds throughout physics, and not only in the special case of gravitation. But there is nothing that could be properly called "cause" and nothing that could be properly called "effect" in such a system.
>
> (Russell 1912–13: 13–4)

In Russell's system, there are two bodies that revolve around a common center of mass. Provided that we know the salient variables, we may calculate how the system evolves. The differential equations incorporate neither the concept of force nor the notion of cause.[6] The equations do not indicate a preferred direction of time. The computation can be done in both ways. The physics of Russell's system gives us no information about causation or the direction of time. One observer could see the planets as revolving clockwise. The direction of this motion is relative, as another observer situated at the complete opposite side of the planets would judge them to be revolving counterclockwise. In the system, one body does not cause any effect on the other. There is nothing temporally asymmetric about the revolving globes.

Matt Farr's argument for directionless time and the C-theory is sympathetic to Russell's. Farr (2020a: 193) considers the famous Humean snooker case. He thinks it supports a C-theoretic view of temporal order. There are roughly three stages in this case: (1) The stick interacts with the cue ball, commencing its motion (while the object ball remains at rest). (2) The cue ball interacts with the object ball. (3) The object ball accelerates (while the cue ball comes to a halt). In a physically ideal situation, the process is perfectly temporally symmetric. We can state that stage 2 is between 1 and 3. There is a definite order but no inherent direction.

The example Russell provides is not expressly causal. This is analogous to the bullet list provided by Huemer and Kovitz. The list consists of fringe cases of causation.[7] In such examples, there is no identifiable causal chain. When events stand in a causal chain, they have a direction. A clear example of a causal chain is the history of life on our planet. The energy of the Sun is responsible for the origin and evolution of species on Earth, which enables me to write or for someone to read these sentences. This process is temporally arranged. First, there are the nuclear reactions in the Sun, then four billion years of evolution and after that a philosophical *Homo sapiens* pondering the passage of time. The three events in the scenario are in no circumstance symmetrical. Philosophers do not cause the evolution of life, and life on Earth does not cause the fusion reactions in the Sun. The later events do not bring about the earlier events. McBreen (2018: 16) hits the nail on its head: "It is in thinking about things causally that we understand that a sequence of events can only happen in one direction." The core difference-making and counterfactual dependence are understandable on the condition that the sequence happens in one direction.

Arguments like these maintain that we humans are part of the causal network of the world. This might sound like a trivial statement. Accepting this statement requires that causation is something more than merely anthropomorphic projection or agentive manipulation. Sam Baron, Kristie Miller, and Jonathan Tallant (2021) analyze the implication of antirealism about time to causation. The main aim of their paper is to develop an account of temporal fictionalism, a topic I deal with in Chapter 5. Here it suffices to introduce the basic idea, specifically how it relates to causation and agency. Fundamental physical theories, like quantum gravity, possibly indicate a timeless conception of the world. Ultimately there is nothing temporal, not even the C-series. It is still a fact that we have temporal thoughts. Folks act in various temporal ways because of their agentive thought. There could not be agentive thought without temporal thought. If causation is real,

> then we can make a difference to the world: we can cause things to happen. Moreover, things will happen to us, things to which we will very much need to respond. If one can in fact make a difference to the world causally speaking, and the world can make a difference to us, then eliminating agentive thought seems disastrous. If we eliminate agentive thought, then we take away any capacity that we might have to reasonably respond to the environment around us in a meaningful way. Our interaction with the world would be limited to reflex and instinctive impulse, rather than high-level cognition and decision-making. It is hard to overstate how radically this would alter the kinds of live[s] we would live, and, for many of us, alter them for the worse.
>
> (Baron et al. 2021: 292)

Baron et al. go on to argue for a fictionalist error theory of causal thought: we have truth-app causal thoughts, but they are, strictly speaking, false. If one accepts this conclusion, the temporal causal sequence I sketched earlier, Nuclear reactions in the Sun → Evolution on Earth → Philosophers debating time, would be a fiction. There is no temporal order, no causation, except in our thoughts. Strictly speaking, we are in error when it comes to identifying the causal relations within our solar system and life on our home planet. If one assumes such a radical error fictionalism, it seems hard to place us, the agents, in the causal chains of nature in the first place. This is not to say that causation lacks agentive features or that theories of causation that emphasize agency are wrong. The point is instead that treating causation merely as agentive leads to a kind of causal antirealism that does not allow the placing of us in the causal network of the world.

This leads us to the question of how fundamental causation is. An important background for the Humean sequential theory of causation is early modern natural philosophy.[8] The core problem for great many European natural philosophers during the 17th and even the 18th centuries was how to explicate the collision of objects. It is no wonder that Hume was concerned with billiard balls in his philosophy of causation (Brading and Stan 2021: 316). James Ladyman and Don Ross (2007) note that microbangings, which are applicable to the early modern theories about causation, should not be taken seriously by contemporary scientific metaphysics. For them, causation has similar status to cohesion, forces, and things. Ladyman, Ross, and Spurrett do not urge the elimination of causation. When it is evaluated in relation to the principle of naturalistic closure, it turns out that causation is not a fundamental notion. Naturalistic closure, in short, means that sound metaphysics should be rigidly connected with scientific results, most notably with fundamental physics. In their view, "the correct account of fundamental physics might not itself incorporate any causal structures, mechanisms, or relations" (Ladyman and Ross 2007: 259).

Delimiting the role of causation is understandable from a robustly naturalist viewpoint. It might be that fundamental physics does not employ causation. The anti-causal stance may produce a cogent philosophy of physics. Not everyone agrees. Alyssa Ney (2009), for one, maintains causal foundationalism. Moreover, many special sciences apply causation. Nancy Cartwright (1979) is a staunch critic of anti-causalism. She has argued that eliminating causation would cripple science. She refers to medicine and medical practices in which causes are abundant. James Woodward (2003) has argued that his preferred account, the manipulationist conception of causation, fits a wide range of scientific contexts, including the behavioral and social sciences.

Even if, in fact, the world is ultimately causationless, that fact does not alter the information concerning the temporal order and asymmetry of causal relations. We may speculate that humans have always known that parents' existence precedes their children's existence. Parents cause their children. The knowledge concerning the temporal order of this causal relation does not change in the case we learn more about the microscopic level of fertilization. Biological theories may, in principle, be reduced to chemical theories, which, in turn, might be reduced to physical theories. Whether such reduction is doable or not, it would do nothing to the temporally ordered fact that parents cause their children. Explaining a causal process with a more fundamental theory does not revoke its time direction. In the first chapter, I mentioned Oaklander's (2004: 41–2) example about the leaf changing its color. I, for one, do not know the microscopic scientific explanation of this phenomenon (I have not googled it, either). Nevertheless, I know that the leaf is first, at an earlier time, green, and then, at a later time, it is brown.

Whether causation is relevant for physics depends on what counts as physics and how its relation to metaphysics is delineated. If physics is strictly about mathematical equations, experiments, and observations, causation might not have a place in it. Tim Maudlin (2007: 1; 104) supports a strong form of naturalism:

> metaphysics, insofar as it is concerned with the natural world, can do no better than to reflect on physics. Physical theories provide us with the best handle we have on what there is, and the philosopher's proper task is the interpretation and elucidation of those theories. In particular, when choosing the fundamental posits of one's ontology, one must look to scientific practice rather than to philosophical prejudice.... Metaphysics is ontology. Ontology is the most generic study of what exists. Evidence for what exists, at least in the physical world, is provided solely by empirical research. Hence the proper object of most metaphysics is the careful analysis of our best scientific theories (and especially of fundamental physical theories) with the goal of determining what they imply about the constitution of the physical world.

This book is hospitable to Maudlin's stance as it also interprets and elucidates physical theories, on what they tell us about time. Maudlin clarifies his meta-position also in his article "Physics, Philosophy, and the Nature of Reality" (2015). He points out approvingly "that the place to begin any inquiry into the universe is scientific theory" (Maudlin 2015: 63). However, contemporary theories of physics sometimes do not provide a clear picture of the world. Philosophical insight is needed to assess what the mathematical formalisms of theories tell us about the nature and structure of reality.

I adopt some form of naturalism.[9] Yet I do not subscribe to a radical form of naturalism, according to which, to reiterate Maudlin's position, "metaphysics, insofar as it is concerned with the natural world, can do no better than to reflect on physics." Instead of referring to current varieties of naturalism analyzed in the meta-metaphysical debates (Tahko 2015: Chapter 9), I am more inclined to reinvigorating the concept of natural philosophy.[10] The term *natural philosophy* is typically understood in historical terms. There is some evidence that this term is an obsolete synonym for *physics* (see Chamber's dictionary 1728: 617). Yet natural philosophy involved much more of what we would count as science today.[11] What is important for the definition of natural philosophy is to deny a dichotomy between philosophy and physics or, more broadly, between metaphysics and science. Denying the dichotomy is not the same as denying a difference. The proper definition of natural philosophy, on my account, is that there is a gray area between philosophy and physics. Both overlap in this gray area; it is not solely about the one or the other. To expound on this formulation, consider the following case in the history of science as documented by Thomas Kuhn (1996: 71) in his classic *The Structure of Scientific Revolutions*.

Some Islamic chemists had experimented with metals and knew that burning them increases their weight. Assuming a phlogiston-like theory of burning, it seems odd that a body gains weight in combustion. If the element of phlogiston resides in the bodies, it should evaporate with smoke. For us, an experiment like this should signal that the burning body takes something from the atmosphere. One would expect that this should have tolled the death knell to the idea of a phlogiston. An obvious explanation is that perhaps the early chemists did not understand the relation between weight and mass (in the sense of the quantity of matter). Yet it might be that the researchers carrying out the experiment had different ontological conception(s) of the world. Perhaps they comprehended the relationship between quantity and quality differently. The burned body changes its color; why is this different from the change of weight?

Kuhn's *Structure* is well known for analyzing the historical and sociological factors that play a role in scientists' interpretation of theories and experiments. What is less well known is his point about the centrality of a broader metaphysical picture for science. Thus, Kuhn (1996: 4–5) puts it as follows:

> Effective research scarcely begins before a scientific community thinks it has acquired firm answers to questions like the following: What are the fundamental entities of which the universe is composed? How do these interact with each other and with the senses? What questions may legitimately be asked about such entities and what techniques employed in seeking solutions?

I do not wish to overstress the ontological commitment of physics. Many civil engineering applications, like building of bridges, dams, and sewerage systems, are based on physics. I doubt that in these cases the engineers and construction workers were involved in metaphysics. When one establishes a comprehensive theory of physics, it is hard to see how to avoid ontology altogether. When examining Newton's *Principia*, for example, we see a plethora of interconnected concepts such as mass, force, cause, laws, space, time, and the like. The work is primarily a work of mathematical physics, but it comes with a metaphysics of the natural world.[12] Newton takes many unobservable items into his ontology, including absolute space and time, mass, the force of gravity, and the laws of motion. None of these concepts could be justified by merely looking at our environment. The classical dynamic theory, to paraphrase Kuhn, requires an account of what kinds of entities exist, how they are related, what kind of techniques can be used to study them, and how they interact with our senses.

The anti-causal philosophies of physics arouse from the proto-positivist and positivist philosophies. Within this paradigm, physics is the cognitive enterprise and metaphysics hogwash. It is nevertheless difficult to draw a sharp dividing line between physics and metaphysics. Central to the theory of dynamics is the concept of a force. In discussing Albert's time-reversal invariance thesis, I have conventionally interpreted it as an action performed by an agent. This is clearly a causal definition. In dynamical processes, the application of force starts before the change of motion. Provided that we do not assume a dichotomy between metaphysics and physics, this inference does not add anything unscientific or superfluous to the theory of dynamics. When assessing laws of nature, causation, the direction of time and, for this book, the passage of time we are in a gray area between physics and metaphysics. This gray area is the field of natural philosophy.

Relying on the somewhat Kuhnian notion of a paradigm—which, at minimum, implies that a scientific theory has an ontology—is in tension with the scientifically realist position as assumed in this book. I noted in the introduction that the special theory of relativity is approximately true. That theory says something about reality's own ontological structure. Time dilation, for instance, is not just a theoretical construction. Instead, it is something that exist independently of conscious beings; it is in our natural environment. This can be seen in various circumstances. The rather graphical example I used before is the detection of muons. There are more fundamental theories, special relativity is not an ultimate theory. According to the critical scientific realism of Ilkka Niiniluoto (1999), theories like these are truthlike. Kuhn would deny this. In his *Structure*, he admits that in course of history, newer theories might be better instruments for problem-solving. In this sense, there is an improvement from Aristotle's physics to Newton's up to Einstein's. "But I can see in their succession no coherent direction of ontological development," Kuhn (1996: 206) contends. In his view, a match between the ontology postulated by the theory and what is "really there" is illusive. In an interview Kuhn did with *Scientific American* in the early 1990s, he denied that theories could be either right or wrong. "Whenever you get two people interpreting the same data in different ways," he said, "that's metaphysics" (Horgan 2012).

One can rather unproblematically say that some instances of Newtonian dynamics are truthlike. The simple example I have used to argue for the direction of time is the temporally one-directional causal impact agents make on objects. This is a perfectly commonsensical assertion. Batting a baseball alters its trajectory. The hitter prepares the bat before contact; the swing of their bat, as well as the motion of their body and its contact with the ground, commences before the ball meets the bat. Newtonian dynamics was devised to explain how such macroscopic bodies interact. It was not developed to account for motions close to the speed of light. Newton did not know about the motions of elementary particles or about objects near massive sources of gravities, like black holes. Repudiating scenarios in which an agent causes an object to change its state of motion would be to repudiate Newton's second law in the context in which it is applicable. Particles do not go faster and faster without limit since they asymptotically approach the speed of light. The relativistic expression of momentum does not, however, refute ordinary causal statements about force and acceleration. It takes metaphysics to argue that such causal relations are temporally ordered and directed. Yet such metaphysics is not external or arbitrary to the science.

If the direction of time is denied, it would be very difficult to explain our ordinary perceptions. Maudlin (2007: 123) provides a compelling *reductio* argument for the direction of time. He takes up William's challenge. We can imagine a being or beings for whom time passes in a different direction. These figures appear, for example, in F. Scott Fitzgerald's (1922) short story, as well as in the palindromically titled and released movie *Tenet* (2020). The protagonist of Fitzgerald's essay is Benjamin Button. He is born an old man and then ages in reverse. It is as for him time passes, in some sense, to different direction as to others. Yet he or the others do not note any other differences. Despite that aging goes to opposite directions, everything in the world proceeds the same way. Williams (1951: 469) surmises that "a completely isotropic theory of space-time" is compatible "with the experience and idea of passage." This lends support to the idea that the true nature of spacetime is isotropic. In spacetime, there is simply no preferred direction of time whatsoever. Perhaps on faraway planets, there are beings who have different arrows of time from ours.

It would still be remarkable if causation in perception would not work in the same direction for them as for us. Consider a physical event like an explosion. An observer receives visual and auditory information of the explosion and forms visual and auditory perceptions. The physical event happens first. After the explosion, the information gets transmitted over a period of finite time to the observer. In receiving the visual information, the observer's retina reacts. The photons get transmitted into electric charges that travel via the optic nerve to the brain. It is hard to imagine a being whose physiology would be completely opposite to ours and still have a similar mental world. In this hypothetical creature's physiology, the brain would send an electric signal via the optic nerve which, in turn, would be transduced as light. Then this creature's eyes would emit light so that the light particles should travel to the original location and initiate the chemical reactions that are responsible for the explosion. Moreover, its ear bones would cause the surrounding air molecules to vibrate and transmit sound around. If such creatures exist, they will not have mental lives like ours.[13]

The problem with the thought experiments that turn the direction of time around is that they do not turn every temporal aspect around. In *Tenet*, the protagonist, played by John David Washington, gets temporally inverted by going through a time machine. The movie is obviously a work of fiction that does not claim scientific accuracy (Zemler 2020). It is still interesting to note that after the protagonist travels in a different temporal direction as others, a great many physical processes around him are not inverted. He sees a seagull flying backward, among others. This is still quite a superficial inversion. He still sees and hears in the same temporal order as before. It is not the case that his eyes emit light, which reflects from the bird to the Sun, or that his ears produce sound waves directed at the bird. The direction of causation has not been overturned.

The relational view defended in this book differs from Maudlin's substantivalist view. I am not claiming that there is a self-existing flow that is to be equated with unique passage. Rather the local directions of time are like arrows on a globe (Rovelli 2019: 1329). Depending on the location on the surface of the globe, the arrows point in different directions. There is no unique way to define upwardness. Yet when two arrows are placed right next to each other, and eventually enmeshed, they point to the same direction. One can argue that passages of time are local in this sense. Assuming that there are intelligent mental beings that are roughly like us on other planets far away, their arrow of time could point in a different direction than ours. There is no special direction. No direction is truer than any other direction, in the same way as no arrow on the globe is more upward than any other arrow. They all point upward, but upwardness is not unique. The direction and passage of time are not unique, either. Still, if we could meet up with beings on a planet remote to ours, we should agree on the direction of time. Otherwise, communication would be impossible.

Here another sci-fi thought experiment is in place. In Andy Weir's *Project Hail Mary*, the protagonist travels into a different solar system and meets an alien. They start their communication through a hex wall, as their atmospheres are made of different substances and are of different pressures. They are able to produce and receive auditory messages. The protagonist reflects on their auditory communication:

> There was no pronunciation or inflection of the sounds. Just notes. Like whale song. Except not quite like whale song, because there were several at once. Whale chords, I guess. And he was responding to me. That means he can hear too.
>
> And notably, the sounds were in my range of hearing. Some of the notes were low, some of them high. But definitely audible. That alone is amazing when I think about it. He's from a different planet, and totally different evolutionary line, but we ended up with compatible sound ranges.
>
> (Weir 2021: 176)

Weir's novel, as well as his previous *The Martian* (2014), are surely works of fiction. But they are in many ways scientifically accurate. Considering all the science involved in this scenario—in the communication of human and alien—there is nothing that should make us think that time does not have a direction. When the protagonist speaks and the alien hears his message, his speaking occurs before they hear. And when he receives information from them, he hears after they have spoken. For both, time is directed in same direction. Along the way time passes. Nothing extraordinary is meant by this: after an hour of chat, both communicators are one hour older.

## Notes

1 Latham, Miller, and Norton (2021) have investigated people's ideas on the direction and existence of time empirically.
2 This calculation is a modification of Dowden's (2020, Section 12).
3 Hume's argument for the temporal priority of causes is a form of *reductio*. Todd Ryan (2003: 30) expounds on Hume:

> If every effect occurs simultaneously with its cause, then we arrive at the absurd conclusion that there can be no causal (or indeed temporal) succession in the world. Therefore, the original assumption that a cause may be perfectly co-temporary with its effect must be false.

He was not confident of his own argument's explanatory power, as he dismissively characterizes it:

> If this argument appear[s] satisfactory, 'tis well. If not, I beg the reader to allow me the same liberty, which I have us'd in the preceding case, of supposing it such. For he shall find, that the affair is of no great importance. (T 1.3.2.8; SBN 76)

4 This is explained very clearly by Bouton (2017: 103–4).

5 I do not favor Mellor's view over Hume's on the anachronistic grounds that Mellor's view can handle relativity. Rather, I take Mellor's theory to supplement Hume's.

6 In a two-body system, Newton's second law yields $\frac{d^2\boldsymbol{r}_1}{dt^2} = G\frac{m_2}{r^3}\boldsymbol{r}$, $\frac{d^2\boldsymbol{r}_2}{dt^2} = -G\frac{m_1}{r^3}\boldsymbol{r}$. The concept of force or cause does not appear in these equations.

7 One might say that the harmonic oscillator also counts as a fringe case of causation. Even in this case, however, one could find causal components in the motion of the mass. Smith (2010: 371–2) argues that the linear restoring force can be taken to be the cause of the sinusoidal oscillation pattern. The initial conditions are responsible for the maximal amplitude, and the specific frequency is caused by the strength of the restoring constant.

8 This is what I have argued elsewhere (Slavov 2020b: Chapter 4). Boehm (2013) disagrees. She has argued that Hume establishes a foundational project. Other branches of study, like natural philosophy, are dependent on his science of human nature. "The sole end of" his "logic is to explain the principles and operations of our reasoning faculty, and the nature of our ideas" (T Intro 5; SBN xv-vi). The search for ideas is of central importance in Hume's methodology. *Treatise* 1.3.2 is largely devoted to the consideration of "the idea of causation" and its origin (T 1.3.2.4; SBN 74–5). This is the ordinary person's idea of causation. Causation is not to be found from any quality of objects as it is a relation among objects. This relation is identified with experience (as Hume explicitly notes earlier in T 1.3.1.1 (SBN 69–70): "'tis evident *cause* and *effect* are relations, of which we receive information from experience"). We observe an object A taking place before object B, and then we experience multiple instances of A's preceding B's. We respectively call A the cause and B the effect. This is a result of Hume's science of human nature, not any form of natural philosophical inquiry.

9 Naturalistic metaphysics comes in different degrees. Morganti and Tahko (2017: 2558–9) defend a moderate naturalism. In their analysis, the relationship between science and metaphysics can be characterized by four points: (1) no overlap regarding methods or subject matter; (2) overlapping subject matter, distinct methods; (3) overlapping methods, distinct subject matter; and (4) overlapping methods and subject matter. Morganti and Tahko favor the second option. In their view, metaphysics, in conjunction with empirical science, provides information about the nature and structure of reality. Although a properly naturalistic metaphysics shares the same subject matter with scientific inquiry, it is still methodologically an aprioristic enterprise.

10 The renaissance of natural philosophy is also urged by Smolin and Unger (2015) and Maxwell (2017).

11 For this point, see Slavov (2020b: Chapter 1).

12 As well as theology.

13 Note that the point is not to claim that perception is passive reception. Perception may very well be an active and constructive process. The constructive nature of perception does not, however, change the direction of causation, and therefore, it does not bear on the direction of time.

# 4 We experience *and* misconceive passage

Simon Prosser (2016) develops two crucial arguments against the possibility of measuring passage, the detector and the multidetector arguments. The detector argument aims to establish that our experience of time is not best described by the A-theory. For its part, the multidetector argument concludes that passage cannot even be experienced. Whereas we can and do construct devices that measure things like temperature, we could not construct a device that measures passage. No physical system detects the passage of time. The upshot of Prosser's argument is that not only has no one ever experienced passage, but no one could ever experience passage.

The suggestion that passage is not detectable is not new. Pre-relativists like Newton thought so. After relativity gained currency, scientists such as Arthur Eddington (1928: 91) remarked that "consciousness, looking out through a private door, can learn by direct insight an underlying character of the world which physical measurements do not betray." The underlying idea is that as relativity suggests reality is four-dimensional, and the dimension of time is similar and intertwined with spatial dimensions, there is an independent consciousness that somehow moves along events spread around a static spacetime. Prosser points out that Eddington's view is not acceptable anymore. Any theory of the mind–body relation that is widely approved by contemporary philosophers of mind must hold that "if no physical system can detect the passage of time then neither can the human mind" (Prosser 2016: 35). In other words, Prosser's argument depends on the acceptability of physicalism. According to a generic definition, physicalism maintains that everything (i) is physical or (ii) supervenes on the physical (Stoljar 2017).

The identity theory fits with (i). In the identity theory, the mind is a physical system. If there cannot be physical systems that detect time's passing, then no mind can detect the passage of time. A less rigid version of physicalism centers around (ii). One does not need to hold that the mind is numerically identical to the brain. Rather, the mental supervenes on the physical. Robin Gordon Brown and James Ladyman (2019: 110)

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specify the concept of supervenience: "*A supervenes on B if there can be no change in A unless there is a change in B*." Physicalism has been criticized in the philosophy of mind for not expounding on consciousness, qualia, and multiple realizability. In the context of this discussion, physicalism is a broad claim about the nature of the world and about different levels of fundamentality. Essential to Prosser's detector argument is the minimal physicalist requirement of supervenience: it is not possible that two mental worlds differ without differing physically. The case is analogous to a dot-matrix picture. There cannot be two separate pictures of the global shapes of the matrix without there being a difference on the dot level (Lewis 1986a: 14).

As noted before, Prosser's argument is divided into detector and multidetector arguments. The detector argument involves a machine with a light on its top. In case time passes, the light turns on. It is quite straightforward that neither the A-series nor the B-series conforms to the way the simple detector ought to work. Both series contain the same event *x*. Its existence is not disputed. If time passes, it should somehow first approach *x* and then receive from *x*. This becoming should luminate the light. Neither of the series explains, in any way, how a turning on the light relates to passage with respect to *x*. Whether the A- or B-theory is the right explanation of the nature of time has no bearing on whether the light illuminates or not. Accordingly, no physical system may detect the passing of time, whether passage is defined either in A-theoretic or in B-theoretic terms (Prosser 2016: 34).

For its part, the multidetector machine has several lights and so could potentially detect the rate of passage of time via successive lights. For the machine to produce some output, Prosser (2016: 43) claims that

> for the illumination of light *L* to be a detection of *f*, the following two necessary conditions must obtain. Firstly, the illumination of *L* must be caused by the instantiation of *f*. For it is not plausible that any detector can detect phenomena from which it is causally isolated. Moreover, the causal mechanism that leads to the illumination of *L* should not also lead to the illumination of the other lights. Secondly, *L*'s illumination must be counterfactually dependent on the presence of *f*. That is to say, if *f* were not instantiated, *L* would not illuminate. Again, this should apply to *L* without thereby applying to all other lights.

*L* detects *f* if there is an identifiable causal mechanism *f* that brings about *L*. In the absence of *f*, *L* does not light up. Compare this to temperature. The average kinetic energy of the molecules of a system is directly proportional to the reading of a thermometer. The motions of the molecules are causally productive of and counterfactually dependent on the system's temperature. Mental beings also register temperature. We notice changes in temperature because its physical base changes. If I open a window on a cold winter day, the more rapidly moving air molecules of my apartment lose their energy to the more slowly moving molecules outside. My feeling of getting colder is caused by and is counterfactually connected to the more fundamental physical level of reality. The multidetector argument propounds that there is nothing like this concerning the passage of time. There is no clearly recognizable mechanism that causes our putative experience of time's passage. Assuming that the mental supervenes on the physical, a point that I am in agreement with, there cannot be any experience of passage.

I find Prosser's argument acceptable,[1] if it is assumed that the passage of time is a substantial feature of the world. The substantivalist thesis, to reiterate, treats the passage of time as a fundamental feature of the world, something that exists independently of the material content of spacetime. If the passage of time is somehow immaterial, then surely no physical system detects it. Hence, no experience of passage supervenes, because there is nothing to supervene on. This reasoning does not, however, debunk relational passage.

I have urged that a commonsensical experience of our changing environment is relevant for the evidence we have of the passage of time. This leads us to the question of what kind of evidence and reasoning is proper for assessing the ontology of time. What is the epistemic standard for detecting passage? Prosser indicates that a commonsensical and experiential approach does not suffice to settle a debate between different metaphysical accounts on the nature of time. He allows that the empirical/conceptual distinction is not that strong in contemporary metaphysics. I think Tahko's (2011) argument for the bootstrapping nature of the relation between *a priori* and *a posteriori* is a case in point. Still, Prosser thinks experience does not weigh in on metaphysical disputes. Graig Callender (2012) has a similar argument: experience does not distinguish between eternalism, presentism, or the growing block theory. In the view of Prosser (2016: 23),

> there is something very odd about being told that a metaphysical debate can be settled by *just looking* (or just *experiencing*, at any rate). It is hard to think of any other metaphysical dispute [outside of the metaphysics of time] where it has been suggested that the dispute can be settled in that way.

Yes, metaphysical debates cannot simply be decided by looking. But this should not entail that experience and empirical evidence bear no relevance to them. Consider the following description of passage by Robin Le Poidevin (2007: 76): "We just *see* time passing in front us, in the movement of a second hand around a clock, or the falling of sand through an hourglass, or indeed any motion or change at all."[2] It is important not to misread this quote. The visual experience by itself does not evidence the existence of passage in any simple way. There are a great many dialectical arguments at play. Defending the reality of passage requires considering a plethora of interrelated problems. These include, for example, historical development of ideas of passage, what special sciences like physics, psychology, and anthropology tell us about time, and what are causation, laws of nature, supervenience, and the like. Among the great many relevant factors, our feeling the passing of time is important. This feeling originates in the usual, everyday experiences of various changes.

The eternalist–relativist position that I have assumed in this book does not treat A-locations as fundamental features of the world. The ontological status of spatial positions and colors is analogous (not entirely equal, of course) to tensed locations. As places and colors are not fundamental, I do not think reality is inherently tensed. Passage is, however, a far more mundane phenomenon than anything postulated by metaphysical grounding relations. If passage is not treated as metaphysically fundamental notion (like Maudlin has it) but rather as something relational that arouses from the natural world around us, commonsensical experience is one piece of evidence in favor of the reality of passage.

One can construct a device that measures the passage, or lapse or duration, of time. Natural uniformities are used to devise clocks. Prosser certainly takes this into consideration. On the condition that the B-theory is true, clocks measure the lengths of temporal intervals. In B-theoretic terms, this is the temporal distance between two events, the first taking place earlier than the second, and the second taking place later than the first. He allows the "complications about the relativistic time dilation" and denounces that clocks measure passage:

> Given that this B-theoretic interpretation is available, we may quite properly say that one hour has 'passed' in everyday talk without begging any questions. For B-theorists do not usually propose that we change the way we ordinarily speak about time in non-philosophical contexts; instead, they offer interpretations of such talk that are consistent with the B-theory. But in the context of the debate between the A-theory and the B-theory, where we reserve the use of 'passage' for the A-theoretic notion, it would beg the question against the B-theorist to say that clocks measure the passing of time.
>
> (Prosser 2016: 33)

If passage is defined in A-theoretic means—future approaches, becomes present, and then becomes ever-more past—passage is not detectable. No machinery registers the putatively robust self-sustaining flux of time. I do not think, as I argued earlier in the first part, that there is A-theoretic passage, defined in terms of changing moments. Such a putative passage is neither a subject of experience nor a mind-independent structure. Yet clocks measure lapses and durations between events. Lapses and durations are depended on motions and gravitational potentials. Prosser (2016: 20) thinks this is irrelevant for passage in B-theoretic terms:

> a B-theorist should say something like this: according to STR, the world line of an object moving with velocity $v$ is stretched along the time dimension by a factor of $1/\sqrt{(1 - v^2/c^2)}$. This says nothing about passage, let alone the rate of passage, but accounts perfectly well for the difference in clock time between stationary and moving clocks.

I disagree with this, as argued in the Chapter 2, as I think lapse of time may not be sharply distinguished from passage. Proper time remains invariant; it is what tracks becoming, the physical processes that come to be. The definite quantity of passage is measured as an integral along the worldline. It is relative to the specific path through spacetime but not to the coordinate system chosen to compute it.

There is still the matter of how fast time passes. For a metaphysical theory of passage, a mere reference to phenomenological experience—time passes more slowly for a person who thinks a movie is boring than for someone who thinks it is entertaining—won't do. Although the ubiquitous change that we witness in ourselves and in our environment, and our passive reception of being "taken to" later times is relevant for verifying the existence of relational passage, this theory does not lean on subjective time. Savitt lists several ways of how one can account for the rate of passage. These strategies apply within the deflationary framework. He concludes that "we have the odd result that all massive objects have the same speed in spacetime, 1" (Savitt 2009: 355–6).[3] "This result holds," he clarifies, "for an object in its rest frame, when it is not moving through space at all. There is only one dimension left in which it has this speed, then, the temporal dimension" (Savitt 2009: 360). A stationary observer moves along their worldline at the speed of coordinate time per proper time, $(dt/d\tau) = 1$. For an observer moving on any spatial dimension, that is, yielding greater than zero value for $(dx/d\tau)$, $(dy/d\tau)$, or $(dz/d\tau)$, the rate of passage of coordinate time per proper time is less than 1. As Maudlin concluded, the limiting rate one dollar per dollar is as good as one second per second.

We may meaningfully say that the passage of time is a fact, but the rate of that passage is relative to the path in spacetime and the closeness to a source of gravitation. Straight paths yield number one and curved paths numbers smaller than one. According to relationism, no time is truer than any other. There is no absolute standard for the synchronization of clocks, like Newton's self-sustaining flow of time itself. Time passes at different rates relative to different observers. The notion of "different rate" is meaningful only when two clocks are compared. Here is a typical science-fiction example that is still in accordance with scientific prediction. A mother sets out to a space trip with a spaceship whose velocity is close to the speed of light. Her infant son stays on Earth. When she gets back, she is younger than her son. Time passes for both, and in their own reference frames, they do not note any difference. When they compare their clocks, which, in this case, are their bodies, they conclude that a different amount of time has passed. How much time passes is relative. The fact that it passes is not.[4] Both are older; both have progressed from earlier times to later times.

Akiko M. Frischhut (2015) argues that we do not have experiences of the passage of time. She claims that our folk intuitions about passage are wrong: we do not experience passage in virtue of experiencing change. We could, in her account, perceive a change in a world that lacks passage altogether. Frischhut thinks there is some confusion about how we intuitively think of passage:

> 'Two hours have passed since I put the roast in the oven, it is done now' or 'Time seems to pass very quickly when you are reading a gripping novel'. Such a view is based on confusion though. Both statements do not refer to anything but the *duration* of time it takes for some change to occur.... There is nothing in these statements which refers uniquely to temporal passage and which is not applicable to mere change or duration without temporal passage. Although it might be true that experiences of change motivate us to believe that time passes, we do not experience passage in experiencing change. Moreover, we cannot infer temporal passage from our experience of change.
>
> (Frischhut 2015: 146)

There are two main points I disagree with. First, I think it is correct to assimilate "*duration* of time it takes for some change to occur" into "temporal passage." As I argued in Chapter 2, whereas we may present spatial intervals with analytic geometry, presenting temporal intervals with analytic geometry leaves something dynamic out. Spatial extension is not the same as temporal extension, as the latter involves succession. This succession is the dynamic feature of the scenario; we can locate the passage of time in this change. This is applicable to both of Frischhut's example sentences. I put a roast in the oven. There are all sorts of dynamic processes going on in the oven, in the kitchen, in my mind, and so on. The same goes for reading a book: my eyes move from sentence to sentence, pages are turned, I change my grip on the cover of the book, and so on. In both cases, there are successive events starting from the beginning of the process and heading toward its end. The designated temporal interval encompasses these successive changes. Here it should be clarified what the aim of Frischhut's criticism is. She agrees that duration involves succession. In her account, the alleged experience of passage is reduced to an experience of one thing happening after another. She does not criticize a relational, or deflationary, account of passage but the traditional A-theoretic robust view. That view involves an objective moving 'now.' Frischhut's argument does not therefore exclude a revisionist theory of passage; it is not directed against it in the first place.

Second, according to the relational theory of passage, we do "infer temporal passage from our experience of change." Frischhut allows that "it might be true that experiences of change motivate us to believe that time passes," but "we do not experience passage in experiencing change." She considers this to be a false assumption, based on three latent premises: (i) we have experiences of change, (ii) change entails passage, and (iii) if *p* implies *q*, then the experience of *p* implies *q*.

(i) In Frischhut's example, we do not perceptually experience a change in a chameleon's colors. Rather, we observe its color at one time, other color at other time, and then, based on our memory, infer that it has changed its color. She allows that we are all aware of some kind of change. The issue at stake is this: Can one be aware of change only from the viewpoint of one's current perceptual experience? I think the answer is no. The terminology in this context is not explicit. To draw on the Humean account, perception and experience should be separated. Perception is something instant. We need memory to connect different perceptions. If there is nothing that connects distinct perceptions, we could never experience anything.[5] Say I see snow for the first time in my life.[6] I perceive a white extended object. I could not know that it has the attribute of coldness. The only way for me to know it is cold is to touch the snow. The experience of snow's coldness requires more than one perception, that is more than one touch, and a memory of the sensory quality of snow, that is, what does coldness feel like. After I have acquired the information of snow's coldness via experience, via multiple sense-perceptions, I could lose this information in case my memory deteriorates considerably. I have veridical belief of snow's coldness based on my mundane experience. The fact that this requires making an inference of connecting memory traces does nothing to refute the source of my belief, to wit, experience. Analogously, the source of my belief in the passage of time is the day-to-day experience of changes in us and around us. Note that this reasoning does not depend on the issue of whether there is a specious present.

(ii) Frischhut strictly denies that change entails passage. She subscribes to a standard view of change, according to which an object changes in case it has incompatible properties at different times. The fact that an object has numerically distinct properties at a different time does not entail passage. Frischhut thinks we typically associate change with succession. This leads us to the wrong track:

> To experience ordinary change *just is* to experience a succession of qualitatively distinct events. In other words, change *looks like* one thing happening after the other in experience. When we see a chameleon changing from red to green for example, we see that change as a succession of two events, first an event 'chameleon-being-red', followed by another event 'chameleon-being-green'.
>
> (Frischhut 2015: 148)

According to a B-theoretic deflationary theory of passage, time passes from the chameleon being red to it being green. There is a successive causal relation. The animal has first, at an earlier time, certain color. The animal is part of the natural world, part of the causal network. The effected change of color is posterior to the causes that bring it about. Its green color has become due to everything that has taken place along its timelike worldline. Becoming is about the change that occurs along the worldline. Frischhut (2015: 148) does not accept this, because in her account "neither the fact that things succeed each other, nor the fact that some things take time entails that time passes."

(iii) Frischhut (2015: 147) maintains that when *p* and *q* are connected, this itself does not imply that the experience of *p* entails the experience of *q*. To be specific, even if change and passage are connected, it does not follow that the experience of change implies that of passage. To bolster her case, she provides the following comparison:

> For example, somebody might possess the concept of a triangle, and the concept of a geometrical figure, but not experience that there is a geometrical figure, when they experience that there is a triangle. So even if a subject possessed the concepts of 'change' and 'temporal passage', and those concepts were connected, it does not straightforwardly follow that they would experience passage whenever they experienced change.

I assume the quote should have a triangle and a geometrical figure the other way around. If one possesses the concept of a geometrical figure, this does not automatically entail that of a triangle.[7] One might be thinking of a rectangle, for example. I agree that change does not automatically imply passage. Change might be affiliated to other temporal notions like duration. When a realist about passage points to mundane experiences, they do not necessarily imply that our experience of the changing environment verifies the existence of passage *simpliciter*. Connecting change and passage requires multiple additional arguments and specifications.

Kristie Miller (2019) provides a plausible account of our concept of A-theoretic passage. In her view, our temporal phenomenology contains the experience of events being in a certain order, of being separated by a certain temporal distance, and of having some durations. We experience events as occurring in a succession. Miller goes through a variety of theories that account for our hypothetical passage phenomenology, including the veridical passage thesis, phenomenal illusion thesis, and the cognitive error thesis.

The veridical passage thesis premises that we have truthlike experiences of the passage of time. The problem is that although we experience a dynamic world, it could be truly static. The color phi experiment might be taken to lend support to this hypothesis. In the experiment, we see (erroneously) a persistent colored blob moving from left to right. It appears to change its color. Our experience is not veridical because there is no one blob but two blobs, and there is no motion from left to right. We somehow construct the dynamic scenario. L. A. Paul (2010: 351) argues that the color phi experiment shows that our brains create an illusion of animation and qualitative color change. In her view, "just as with cases of apparent motion (and with color phi in particular), we experience an illusory sense as of flow and change as the result of the brain's need to accommodate the contrasts between the stages $t_1$ and $t_2$" (Paul 2010: 352). There is a colored twinkle at time $t_1$ and a different colored twinkle at $t_2$ but no flow from $t_1$ to $t_2$.

The phenomenal illusion thesis indicates that the persisting flow of time from past to future is a delusion, generated by us. This could be compared to other illusions than the color phi phenomenon. Say someone spins rapidly multiple times. After they stop spinning, the environment seems to move around them. It does not: that is the illusion. This is "created," Paul Davies (2002: 47) explicates, "by the rotation of fluid in the inner ear. Perhaps temporal flux is similar." There are great many still images that appear to undergo change. Our experience of passage of time might be a similar kind of illusion. There are other experiments that provide evidence for the view that our temporal experience is not (at least completely) veridical. These include, for example, the flash-lag effect, the cutaneous rabbit, cross-saccadic perceptual continuity, motion aftereffect, and peripheral drift (Bardon 2013: 44–8; Farr 2020b: 13).

What cases like these show is that the temporal order of the raw sense data may not correspond exactly with our temporal experience. This is true at least on small time scales (from a human point of view), on the scale of some hundreds of milliseconds. Yet the experiments do not provide evidence for the static nature of the world. That is what they should do to render passage illusory. There are changes from earlier times to later times. On short temporal scales, we might get the order wrong, but this is insignificant for the reality of passage. Change is responsible for passage.

I think that a more promising account of our misconception of A-theoretic passage comes from a version of the cognitive error thesis, specifically the misdiscreptionist position. Linguistic communities conceptualize time in various ways by speaking about it, writing it down, and reading it aloud. There is experimental psychological evidence that lends support to the misdecriptionist theory.[8] This suggests that "*if* we misdescribe our experiences using passage-friendly language, then we could indeed come to believe that those experiences are experiences as of passage" (Miller 2019: 27). Humans have, in some way, developed a language that resorts to passage, even though they lack a passage phenomenology.

Together with Alex Holcombe and Andrew James Latham, Miller (2020) argues that we believe in the passage of time because our language is imbued with passage. Passage-friendly language is both the cause of our belief in time's passing and the source of our misdescription of our supposed passage phenomenology. The underlying assumption is that all languages are at least minimally passage-friendly. There are tenseless languages that apply aspects and moods. 'I'm eating a sandwich" (aspect) and 'Don't forget to shut the door' (mood) describe situations that are extended over time, not something changing over time. Still, languages recognize presentness and include time deixis in which a subject situates themselves to some temporal perspective that relates the time of the utterance to some degree of pastness and futurity of events (Gell 1992; Sinha and Gärdenforss 2014).

Languages express temporal perspectives. Other times are related to our present perspective. Despite linguistic differences between cultures, it is typical to depict time as moving or us moving through time. This minimal dynamic notion is embedded in a variety of languages. The universality of a passage-induced language might be explained by evolutionary considerations. Maclaurin and Dyke (2002) argue that tensed emotions are adaptations. In their definition of 'adaptation,' it is the behavior or capacity that confers "reproductive advantage upon the species in question for some large portion of its history" (Maclaurin and Dyke 2002: fn. 5). Although all events might be real from a metaphysical point of view, which is the eternalist position assumed in this book, our emotional responses vary to different events. "All events being equally real," Adrian Bardon (2013: 108) expounds on Maclaurin's and Dyke's contribution,

> doesn't mean that all events deserve the same emotional response every time we think about them; it is essential to our prospects of survival that we respond differentially to events according to their causal relation to us at any given time, and we should expect this to be reflected in our emotions.

Feelings like dread are directed at future, whereas relief relates us to the past. These tensed adaptations, roughly and broadly, form the basis for our conception of changing time, of our misdescription of tensed passage.

There are reasons to be cautious about evolutionary psychological explanations that refer to adaptations.[9] Subrena E. Smith (2020) criticizes evolutionary psychology on many accounts. She argues, among others, that evolutionary psychological explanations are subject to the matching problem. How do we ascertain that our current behavior matches the cognitive mechanism of our prehistoric ancestors? Despite Smith rejecting the inferential strategies of the strong form of the research program that relies on massive modularity, she still respects broadly evolutionary explanations: "No one should contest that the human mind is a product of evolution, and evolution must therefore enter into an explanation of human psychology in some way" (Smith 2020: 48).

It is hard to imagine how humans could plan and navigate in everyday social circumstances without a recourse to temporal perspectives. Given how widespread temporal thinking and language are, it would be remarkable if it did not relate to natural selection. The human species is a product of natural selection. Our species is just one species among other species. There is some evidence and reasons to think that nonhuman animals are engaged in mental time-travel, in which an individual of a species could travel back or forth in one's mind's eye to recall (episodic memory) or imagine future needs (episodic prospection; Haun et al. 200–2). Dreading danger might have helped our ancestors avoid violent conflicts and develop safer hunting techniques. Future-oriented feelings are plausibly related to fear, which is a strategy to minimize pain. Past-oriented feelings have a different function because we cannot affect the past. Dyke and Maclaurin speculate that relief connects to our highly developed sense of danger. When a dangerous situation is over, we at that time no longer have to consume massive amounts of adrenaline trying to avert the situation. Hence, we are relieved (Maclaurin and Dyke 2002: Section 6).

From an eternalist and B-theoretic perspective, the distinction between the past, the present, and the future is deeply emotional. Defenders of A-metaphysics would, of course, not accept this, because for them A-series is intended to yield a profound theory about the nature of time. From an eternalist point of view, we can make sense of the idea that tense is emotional by considering the following event: dentist drills my tooth. The event 'Dentist drills my tooth' is very different to me, if it is in the future, in the present, or in the past. Apprehensiveness, pain, and relief are responses to the very same event. In the physical description, past, present, and future are specific spatiotemporal perspectives; in the metaphysical description, past, present, and future are equally real. The difference among A-locations is nothing substantial: it is subjective. Such subjectivity does not entail anything derogatory. Describing the world with tensed language is very important for us in a great many ways.

If it is the case that all languages apply passage metaphors, it is probable that these metaphors are productive of the evolutionary history of our species. This would account for the ubiquitousness of passage-friendly talk and thinking. This point connects to an earlier argument of mine that compares the existence of tense to the existence of colors. According to perspectival realism, both tensed locations and colors are perspectivally real. In our everyday lives, we do not recognize that statements like 'Grass is green' are made from a perspective. The statement 'Grass is green' is, however, true in the observer's rest frame. Another observer approaching the grass with a great enough velocity would perceive the grass as blue, and another observer receding from the grass would perceive it as red. For the three observers, the statements 'Grass is green,' 'Grass is blue,' and 'Grass is red' are all true in their own frames of reference. In the same way, in our everyday lives, we do not recognize that statements like 'The water boils over is simultaneous with starting the dishwasher' are made from a perspective. This statement is true in the observer's rest frame. Another observer approaching the boiling water could see it spill before the dishwasher sets off and conversely for an observer moving toward the dishwasher and away from the pot. The Doppler effect for electromagnetic spectrum (but not for sound waves) and the relativity of simultaneity are negligible to our raw senses. Our moving is significantly slower than the speed of light, and the gravitational potential differences on the surface of Earth are not that significant. The point is not that relativistic effects do not affect us. To the contrary, they affect us humans all the time. The point I wish to make is that our species has evolved in an environment in which the relativity of colors and temporal order is not visible. We misdescribe the ontological status of colors like 'green' and tensed positions like 'now' because our senses do not catch up with the relevant effects. This is due to the evolutionary history of our species, which has produced for us a certain contingent anatomy, senses, and cognitive processes.

As I do not think A-locations are fundamental, and that time passes between them, the misdescriptionist (Miller et al. 2020) and evolutionary (Maclaurin and Dyke 2002) theories are hospitable to my argument. This chapter did not provide a detailed explanation of how passage became part of many languages and how it connects to evolution. This is a task for researchers in different fields. Yet the more general philosophical positions were articulated. The belief in an A-theoretic passage is a misdescription. This does not render the B-theoretic deflationary account faulty. We can track the succession of events correctly and so detect passage veridically *and* be mistaken about the flow from the future via the now to the past. Accordingly, we both detect *and* misconceive the passage of time.

## Notes

1 For a critical evaluation of the argument, see Deng (2018) and Skow (2018). Deng seems to be receptive of it, whereas Skow thinks it is not a very good one. Prosser (2018) responds.

2 Note that Le Poidevin does not subscribe to realism about passage. Frischhut (2015: 144) lists several quotes in which the passage thesis is taken to be vindicated by experience.

3 This conclusion is based on assimilating the speed of objects in spacetime and the length of the velocity four-vector, which is −1. The invariant quantity $\Delta S^2$ in the four-dimensional spacetime is $-(\Delta t)^2 + (\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2$, in which $t$ is the coordinate temporal dimension and $x, y, z$ are the familiar three spatial dimensions. When this is presented in the infinitesimal form and multiplied by −1 to change the negative quantities, the proper time $\tau$ in $d\tau^2$ is $(dt)^2 - (dx)^2 - (dy)^2 - (dz)^2$. Savitt presents the four-dimensional quantities as four-vectors, in which the four-velocity is $u = \left(\frac{dt}{d\tau}, \frac{dx}{d\tau}, \frac{dy}{d\tau}, \frac{dz}{d\tau}\right)$.

4 I agree with Newman (2021: 67) in that the different rates of passage reinforce the reality of passage: "time passes at different rates along different world lines. The best explanation for the different rates is that time indeed passes."

5 Compare this to Hume's account of experience in the first Book of his *Treatise* (1.3.6.2; SBN 87):

> Tis therefore by experience only, that we can infer the existence of one object from that of another. The nature of experience is this. We remember to have had frequent instances of the existence of one species of objects; and also remember, that the individuals of another species of objects have always attended them, and have existed in a regular order of contiguity and succession with regard to them. Thus we remember to have seen that species of object we call *flame*, and to have felt that species of sensation we call *heat*. We likewise call to mind their constant conjunction in all past instances.

6 This borrows from Hume's use of Adam in the Abstract to his *Treatise*.

7 If one possesses the concept of a triangle, this should automatically entail that of a geometrical figure. All triangles are geometrical figures by definition.

8 Quoted from Miller (2019: 27), the empirical studies are Boroditsky et al. (2011); Boroditsky (2001); Casasanto and Bottini (2014); Chen (2007); Fuhrman et al. (2011); and Fuhrman and Boroditsky (2010).

9 Downes (2018: Section 4) lists a number of critics of the overt form of adaptationism.

# 5 Passage is not a fiction

Sam Baron, Kristie Miller, and Jonathan Tallant (2021) put forward a conditional argument. If certain fundamental physical theories turn out to be true, temporal fictionalism should be the primary theory about temporal thought. Baron et al. acknowledge that the world is full of temporal thoughts, but there are good reasons to think that deep down, the world is timeless. Therefore, our everyday temporal thinking is in error.

Baron et al. (2021: 289) define temporal fictionalism as follows. Mundane temporal thought is truth-app but false. It is still a worthy fiction. We all act and think in temporal ways: it took two minutes to dress up; I had coffee after lunch; it was rainy yesterday. These are useful fictions that enable us to get along in our everyday lives. We believe in temporal fictions the way actors immersed in their roles believe they are the characters they play.

To say that A-locations are not fundamental and that time does not pass in A-theoretic sense is nothing radical. There are famous anti-realists even about the B-theory, like McTaggart (1908) and Barbour (1999). Baron et al. treat even the C-series as fictional. McTaggart identified the C-series over hundred years ago, but he thought it is not temporal. Today, there are proponents of the C-theory, like Matt Farr (2020a). The C-theory contains neither passage nor direction. It encompasses only the symmetrical relation of temporal betweenness. An event B stands between A and C, but there is no direction of time.

The view that time does not ultimately exist finds support in some of the most fundamental hypothetical physical theories. Rovelli (1991, 2004) thinks quantum gravity, which is intended to connect gravity and quantum mechanics, supports a timeless view of the world.[1] In his monograph *Quantum Gravity* (2004: Section 1.3.1) he argues that the development of physics indicates the disposal of time. In classical kinematics and dynamics, time was construed to measure how observable quantities $A$, $B$, $C$… evolve over time. In Rovelli's rendition, Galileo formulated laws for the functions $A(t)$, $B(t)$, $C(t)$. . . Galileo was the first to discover an effective way to measure the variable $t$, hence providing an operational definition for these functions. This required him to realize that

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pendulum oscillations take place at equal times. The next question is, Equal with respect to what? Newton argued for an unobservable $t$, which is required to differentiate acceleration and constant motion. Rovelli does not refer to Mach in this context. In his *Science of Mechanics* (1919: 223), Mach repudiates Newton's absolute time based on his relationism. Saying that the oscillations of the pendulum occur *in* time is misleading. The oscillations depend on the gravity of the Earth. "In the observation of the pendulum," Mach has it,

> we are not under the necessity of taking into account its dependence on the position of the earth, but may compare it with any other thing (the conditions of which of course also depend on the position of the earth), the illusory notion easily arises that *all* the things with which we compare it are unessential. Nay, we may, in attending to the motion of a pendulum, neglect entirely other external things.... Time, accordingly, appears to be some particular and independent thing, on the progress of which the position of the pendulum depends, while the things that we resort to for comparison and choose at random appear to play a wholly collateral part.

Mach (1919: 224) called Newton's absolute time as "an idle metaphysical conception," because this putative time cannot be measured by comparison with any motion. I assume Rovelli does not share Mach's anti-metaphysical approach. He still maintains that time itself is unreachable for us. Rovelli (2004: 30) explains that

> we write equations of motion in terms of this $t$, but we cannot truly access $t$: we can build clocks that give readings $T_1(t)$, $T_2(t)$.... What we actually measure is the evolution of other variables against clocks, namely $A(T_1)$, $B(T_1)$. Furthermore, we can check clocks against one another by measuring the functions $T_1(T_2)$, $T_2(T_3)$. . .

Rovelli holds that there is no such variable $t$ at the Planck scale of quantum gravity. This theory allows the computation of the relations between observable quantities but not the evolution of these quantities over unobservable time. Needless to say, this is bad news for the notion of passage: it is entirely superfluous. Rovelli notes that quantum physics rejects spacetime, in the same way as particles lack determinate trajectories. "Thus, in quantum gravity the notion of spacetime disappears in the same manner in which the notion of trajectory disappears in the quantum theory of a particle" (Rovelli 2004: 31). Although the Schrödinger equation of quantum physics includes the $t$, it disappears from the Wheeler–DeWitt equation. In the view of Rovelli (1991: 442–3), the latter is more fundamental than the former, and the former emerges from the latter.

Time as a part of spacetime is at best an approximation. Baron et al. (2021: 288) claim that in quantum gravitational description of the world,

> there is no 'right way' to order … instants via temporal relations; nor is there any sense in which we can measure temporal distance between events/objects located at different instants. So not only is it not the case that there is a temporal ordering of events from earlier, to later that is directed, there isn't even an undirected temporal ordering of events: there is no C-series.

Baron et al. reject temporal realism and non-cognitivism. They consider two versions of the error theory, eliminativism and fictionalism. They specifically favor pretense fictionalism. Pretense fictionalism suggests that we engage in a temporal fiction by pretending that our temporal thoughts are true. Our temporal thoughts are, strictly speaking, false because the world is timeless.

I think temporal fictionalism has a hard time to explain the difference between simultaneity and apparent simultaneity. Provided that the speed of electromagnetic radiation in vacuum is finite and invariant, consider two inertial frames, *IF* and *IF′*. In both frames, flashlights are switched on at the far end of their one spatial axis. In *IF*, there is an observer O located at the midpoint (Figure 5.1).

In *IF*, the signals reach the observer at the same time. Assuming the isotropic nature of the signals, in *IF* the two events, that is the turning on the flashlights, are simultaneous. The events that are responsible for the observations happen at the same time. Say O then switches to another frame, *IF′*. In *IF′*, O is located at one far end of the frame's axis (Figure 5.2). O receives the signals simultaneously. Given the invariant finite speed of the signals, O must conclude that the events that were responsible for the observations were successive.

In both cases the order of events is frame-dependent. One need not to assume any hyperplane of 'now' that connects or does not connect the

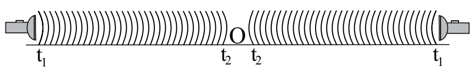


*Figure 5.1* The two events are simultaneous in IF. I have drawn this image; a similar version has been printed previously in Slavov (2018: 236).

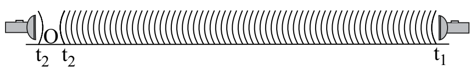


*Figure 5.2* The two events are apparently simultaneous in IF′. I have drawn this image; a similar version has been printed previously in Slavov (2018: 237).

two events. What we have in *IF* and *IF′* are two events that emit signals that reach the observer. Based on these signals the observer receives information about the temporal order of the events in question. There is nothing fictitious about their judgments on temporal order in these scenarios. Think about the case of *IF′*. In this particular frame, there are three logical possibilities of the temporal order of the two events. One happens before the second; one happens after the second; they happen at the same time. If one accepts the light postulate, it is possible to conclude that the temporal order within *IF′* is successive. It is not simultaneous or successive in the reverse order. How could something like this be a fiction? There is one correct answer concerning the temporal order in *IF′*. The other two answers that contradict the one correct answer are false. This reasoning premises the isotropic speed of electromagnetic signals. Einstein (1923) famously thought of this as a convention, whereas Malament's (1977) theorem indicated that it is not. I will not side with either of these views here.[2] The point is that when one accepts the premise of the isotropic speed of electromagnetic signals, one will logically conclude that the two events are successive in *IF′*. It is very possible to reach a truthful understanding of temporal order in a given context, even though this conclusion includes an assumption that cannot be proved.[3]

None of this requires that special relativity or causation are ultimate in any sense. In the specific context, like in *IF′*, the observer O is justified to make their conclusion. O's inference is not based on a pretense *as if* the two events take place successively but on the logical inference that the two events *did occur* successively, although they are perceived simultaneously. In *IF′* O needs to separate appearance and reality. In some cases, two events look simultaneous but are not. Our temporal thinking may very well be both truth-app and truthful. This is analogous to cases in which we correct perceptual information with rational inferences. Consider the picture on the next page. It looks like the railway is getting narrower although the steel is straight.

Baron et al. (2021: 285) raise an interesting question about the ontological dependence of the temporal aspects of the world. They "recognise, of course, that the existence of thought itself seems to depend on the existence of various temporal processes, from the most general (like causal relations between mental states at different times) to the most specific (such as rates of neural firing in particular regions of the brain)." In order there to be thought of any kind, including temporal thought, there needs to be a more fundamental level of reality that itself is temporal. The next sentence reads: "Without time, it is unclear how the physical basis for these thoughts can exist." Here Baron et al. acknowledge that the physical basis must be temporal in some way for there to be thinking. It could be added that there is something paradoxical about claiming there is no time. I must think—this takes some time, thoughts go on in my

*Figure 5.3* The railroad track looks to be getting narrower although it is straight. Photo by Martin Winkler: https://pixabay.com/photos/railway-rocks-sunset-sun-sunlight-1555348/.

mind—that there is no time. The argument for the unreality of time takes place within a temporal interval.

We can get back to the *reductio* argument by Maudlin, which I tweaked a little bit earlier. Considering the physics and physiology of perception, it would be absurd to treat the direction of time as irrelevant or nonexistent. Visual and auditory observations are based on a physical event occurring before the perception and perception after the event. The photons that get transduced into currents that transmit the visual information travel in one direction only. Same for sound pressure and the ensuing currents. This physical basis is necessary for our subjective qualitative perceptions of colors and sounds, of how we feel them from a first-person perspective. The physical interactions between photons, charges, and neurons involve causation and the direction of time. For there to be thought is dependent on there being temporal physical processes.

Under fictionalism, temporal thought is both truth-app and false. The critical question is what those temporal claims are about. Perhaps the world is timeless and causationless "at the bottom." If we allow this, then our temporal thought about "the bottom level" of reality is false. I think the notion of "ultimate level" is problematic. I have criticized it earlier as I think it is a metaphysically inflationary concept (Slavov 2019: 34). In this book, I have assumed a minimally physicalist thesis that draws on supervenience. Minimal physicalism is consonant with the notion of relative fundamentality.[4] Relative fundamentality allows us to assess ontological hierarchies yet remain agnostic about the putative ultimate ground. David Wallace (2013: 262) notes that "we have strong reasons to think that the equations that govern larger-scale physical processes are somehow derivative on, or determined by, those that govern fundamental physics." I do not intend to explain how the larger-scale temporal reality is derivative on the more fundamental scale. We have still good reasons to think the more fundamental exists independently of the less fundamental. In some cases, it might be problematic what counts as more fundamental than the other. For example, it is questionable whether particles or fields are more fundamental.[5] The following ontological hierarchy is nevertheless clear-cut. Elementary particles exist independently of atoms, which, in turn, exist independently of molecules, which, in turn, exist independently of cells, which, in turn, exist independently of temporal thinking.

What is noteworthy is that the less fundamental is ontologically dependent on the more fundamental, but this does not render the less fundamental any less real than the more fundamental. Commonplace statements about the hardness of objects, for example, are true relative to the macroscopic ontological level. There is no hardness in electromagnetic interactions among atoms. In turn, there are no classical electrostatic forces at the level of fundamental particle physics. Despite the ontological hierarchy is very clear on this issue, it does not render ordinary claims about hardness fictional. Proposition "My work desk is hard" is both truth-app and true.

The same applies to ordinary temporal thought. Consider the following scenario, in which I think it is very difficult to see how the claims that are potentially tracking the truth still fail. A lighthouse watchperson has fallen asleep. A ship approaches the shoal of the island in which the lighthouse is located. Luckily, the watchperson wakes up and turns on the light. They turn the light on because they want to prevent the shipwreck. They understand that it is relevant to signal the ship before the potential havoc. In turn, the captain of the ship receives the signal after it has been sent from its source. The captain makes a conscious decision based on the information they have received. There is normative consideration involved: it is bad to wreck the ship and desirable to avoid its destruction. The physicalist interpretation of this situation bestows that everything in the scenario is physical. None of the human actions occurs independently of its material basis. The point of such a physicalism is not, to quote Quine (1981: 98),

> that everything worth saying can be translated into the technical vocabulary of physics; not even that all good science can be translated into that vocabulary. The answer is rather this: nothing happens in the world, not the flutter of an eyelid, not the flicker of a thought, without some redistribution of microphysical states.

Resorting to the notion of relative fundamentality and supervenience physicalism, we may say that there are a plethora of things that may not be reduced to its physical foundation. According to a quantum description, for example, one could calculate the probabilistic outcome of photons and particles of the system. The Schrödinger equation, unlike the normative decisions of human agents, is temporally symmetrical. It might be that at the quantum level there is no temporal direction. It might be that there is no causation, either. There certainly are no information-processing normative beings who make conscious decisions.[6]

When considering obviously temporal instances, like the communication between the watchperson and the captain, we make cognitive claims which can be true about *that* scenario. In the context of theory application, Patrick McGivern (2012: 38) has emphasized the notion of scales of reality. Nonfundamental theories may correctly describe the world and thus provides explanations for it. This is different from a level-based position of theory application, which suggests that theories about the nonfundamental level are strictly speaking false. Mundane temporal thinking is not thinking about the quantum scale. If the more fundamental scale does not conform to our day-to-day temporal thought, it does not follow that our everyday thinking about time is erroneous. It might be that deep down, the world is timeless and causationless. Even if this is true, it does not render all inferences involving time fictitious. In specific contexts, judgments concerning temporal order—notably about the successive relation of being earlier than *x* and later than *x*—are not only truth-app but true. And before/after relations suffice for a mitigated theory of the passage of time.

Rovelli's argument for the nonfundamentality of time points to the fact that there is no one true time over which physical processes evolve. Things do not happen over time. I agree with this in a qualified sense. I do not think processes evolve over a unique time. Rovelli's conventionalist remarks about clock synchronization seem correct to me. A reasoning like this militates against subtantivalist flow of time. In Rovelli's (2004: 30) interpretation, "Newton assumes that a[n] unobservable quantity *t* exists, which flows ('absolute and equal to itself')."[7] Rovelli urges for a timeless metaphysics, but the following concession is interesting:

> Of course, in a specific problem we can choose one variable, decide to treat it as the independent variable, and call it "the" time. For instance a certain clock time, a certain proper time along a certain particle history, or else. The choice is largely arbitrary and generally it is only locally meaningful.
>
> (Rovelli 2004: 31)

The upshot of the quote above is that there *is* a time, "a certain clock time, a certain proper time along a certain particle history." This is enough for relational passage. It takes place along a certain timelike worldline. It is local, not global.

In this chapter, I have been circumspect in my assessment of whether fundamental physics entails a timeless account of the world. My education in physics is too limited to comment on the details of the quantum level. My take on that is necessarily sketchy. Claims about the fundamental level lacking time are, however, ontological in character. In what way does time exist or not exist? What would a timeless world be like? It would not include order or duration, not even betweenness, let alone tense. Still and all, different descriptions of the world involve change. The concept of an event, for one, requires something dynamic. Rovelli agrees with this, as is evident in his popular book *The Order of Time* (2018). Rovelli purports that as the world is made of events, not things, there are ongoing processes deep down. Events are dynamic as opposed to static things. "Change is ubiquitous," he proclaims. In his view,

> [t]he entire evolution of science would suggest that the best grammar for thinking about the world is that of change, not of permanence. Not of being, but of becoming.... We can think of the world as made up of *things*. Of *substances*. Of *entities*. Of something that *is*. Or we can think of it as made up of *events*. Of *happenings*. Of *processes*. Of something that *occurs*. Something that does not last, and that undergoes continual transformation, that is not permanent in time. The destruction of the notion of time in fundamental physics is the crumbling of the first of these two perspectives, not of the second. It is the realization of the ubiquity of impermanence, not of stasis in a motionless time.
>
> (Rovelli 2018: 97)

As Rovelli sees the world ultimately as a network of events, there is change. If there is change, it sounds strange to say that there is no time. Arguably the most pervasive theme one can find in the history of philosophy of time (paradigmatically, in the work of Aristotle) is that time is a measure or dimension of change. If there are physical processes, there is temporality. Compare this to Parmenides's or McTaggart's classical arguments for the unreality of time. Parmenides thought that because describing the world with temporal concepts is contradictory, reality, as opposed to what it seems, is changeless and therefore atemporal. In a similar vein, McTaggart argued that the A-series is internally contradictory, because an event cannot have all three A-properties, past, present, and future. We are left with the B-series. Its before–after relations do not necessarily indicate earlier and later than relations; the C-series encompasses some type of relations, ordering of letters and numbers, for example. But it contains no change and hence no time. And there is the more recent defense of antirealism about time that comes from Barbour, who contends that motion is an illusion and, therefore, time is unreal. If change is essential to Rovelli's metaphysics, why not time? The two are intimately connected. Rovelli does not explain how change and time could be sharply distinguished.

It is not clear to me what kind of realism Rovelli's physics of time admits. In his *Reality Is Not What it Seems*, he points out that time does not appear "in the fundamental theory: the quanta of gravity do not evolve *in* time. Time just counts their interactions." Fundamental equations do not incorporate the variable of time. Yet he writes that "the passing of time is intrinsic to the world, it is born of the world itself, out of the relations between quantum events which *are* the world and which themselves generate their own time." This is clearly an ontologically realist statement about time (confusingly, it is placed in the "Time Does Not Exist" chapter). He notes that time emerges from the quantum gravitational field. One way to explain this emergence is to refer to functionalist explanations. Vincent Lam and Christian Wütrich (2018) have argued that the relation between quantum gravitational and spatiotemporal structures is best understood in terms of functional roles. For instance, spacetime is needed for empirical testing: there needs to be some physical object in some region of space at some time. The 'some place' at 'some time,' that is the specific spatiotemporal region, is the relevant function. Spacetime is as spacetime does. In their subsequent article, they set forth a presuppositional scientific realism about spacetime functionalism. This entails that if the fundamental theory turns out to be non-spatiotemporal, spacetime functionalism would explain how spacetime is born out of non-spatiotemporal physics (Lam and Wütrich 2021). If such an inference is correct, we could not say that spacetime is a container or background of every physical process (Knox 2013: 347).

I do not think, as pointed out earlier, that appeal to a fundamental timeless theory disposes time. If there are changes, like vibrations, scatterings, and decays in the fundamental existence, there is some temporality. Time and change may not be completely disentangled. For a book that works on the assumption of eternalism, effective spacetime might threaten eternalist commitments. After all, it is an ontology of time that maintains all events are spread across spacetime and that whatever event we label as 'now' is due to a specific spatiotemporal perspective.

Baptiste Le Bihan (2020) considers the relation between eternalism and quantum gravity. He assesses the approaches to quantum gravity by analyzing the status of time in string theory and loop quantum gravity. He thinks loop quantum gravity supports eternal atemporalism, but other approaches, like some versions of the string theory, go better with standard eternalism. Whereas standard eternalism indicates that all times exist *simpliciter*, atemporal eternalism indicates that all parts of the natural world exist *simpliciter*. In this sense, "eternalism is only superficially tied to the existence of time" (Le Bihan 2020: 12). This characterization is perhaps surprising at first, since eternalism is a realist theory about time: it predicates the existence of all times.

Eternalism and atemporal eternalism might not be that different. We may target various parts of reality in terms of local times and spacetime regions. The standard version and Le Bihan's (2020: 13) version "agree that the range of existence *simpliciter* does not depend on any vantage point in the (temporal or atemporal) structure: existence is not a *local* matter." Any physical entity exists substantially and independently of our spatiotemporal vantage point. According to atemporal eternalism, however, one may not say that all events are spread across spacetime. Spacetime is effective and hence in no deep sense do events occur in spacetime. Being effective could mean two different things. Spacetime might be effective in the sense that it approximates a more fundamental theory. It could also be that spacetime holds for some scales of energy. Spacetime might be real by being composed from a more fundamental structure that itself is not spatiotemporal. Baron and Le Bihan (forthcoming) investigate this strategy. If spacetime exists in some nonfundamental way, eternalism could be true concerning that level or scale of existence.

Le Bihan's atemporal eternalism is largely in agreement with the way I connect eternalism and perspectival realism about tense. As I argued elsewhere (Slavov 2020a), events exist independently, not moments of time. The existence of a physical event, unlike the existence of past, present, and future times, is independent of setting up a frame of reference. Here we should be careful in how to describe the frame-relativity of facts. One could define perspectivalism roughly as follows: *a* having a property *P* is relative to a frame *F*. If *a* is a physical event, and *P* is a property like the 'now,' then *a* having the property *P* is a frame-relative matter. Whether a generic formulation like this can be literally applied to tense is questionable. According to both standard and atemporal eternalism, events themselves are not associated with any tenses. Viewed from a certain perspective, an event can be past, present, or future. Compare this to other indexical notions. Say an amusement park has a map with a red dot and a text 'You are here.' In this case, 'hereness' is frame-relative. 'Hereness' does not exist substantially. Yet 'here' is not a property of the location you are standing on. This is different from substantive claims like 'Electron has a negative charge.' Charge is an intrinsic property of an electron: it would not be an electron without a charge. For their part, physical events BE as they BE tenselessly. Their existence does not depend on frame-relative facts like 'An event happens "now."'

If quantum gravity does away with ABC theories, fundamentally there are no locations of past, present, and future, or relations of before-than, simultaneous-with, after-than, or in-between. If quantum gravity implies atemporality, there is no room for presentism: there is no robust way to cut the world with a simultaneity slice that connects all events occurring 'now' in an absolute and universal way. Quantum gravity might be hospitable to eternalism, although the atemporal eternalist may perhaps not admit objective temporal order or betweenness. Whether the difference between standard and atemporal eternalism is substantial or fine-grained is a topic for a future study.

## Notes

1 Some, like Gryb and Thébault (2016) and Smolin (2018), depart from this view.
2 For a recent overview of the conventionality of simultaneity, see Thyssen (2019).
3 I have argued (Slavov: 2022) that although conventionality remains, the light postulate is not an arbitrary convention.
4 Tahko (2018) clarifies the relevant concepts in the debate on fundamentality.
5 Sebens (2019) has written a nice popular essay on the topic.
6 Fernandes (2021) has argued that the temporal asymmetry of value does not force us to accept tensed metaphysics.
7 Mach (1919: 224) criticized this uniform flow because motion of any kind may be defined only by comparison to another motion. He thought the concept of motion in itself is meaningless. DiSalle (2002) and Maudlin (2012) take Newton to provide empirical evidence for absolute motion with his rotating water bucket and revolving globes arguments. Maudlin (2012: 45) points out that Mach completely rejects the revolving globes argument: we do not have the faintest idea how the attached globes would act dynamically in an otherwise empty universe. Rejection does not imply refutation.

# 6 Time passes amid perduring objects

Despite the prospects of quantum gravity,[1] Balashov (2010: 5–6) maintains spacetime is very important for much of contemporary physics. This comes with intriguing consequences for the notion of persistence. Thinking in terms of spacetime requires one to depart from a somewhat commonsensical Cartesian viewpoint.

According to Cartesian analytic geometry, a physical object can be depicted as a point within three spatial dimensions. Regions of space endure. The three figures in Figure 6.1 depict an object at rest in three-dimensional space.

In the Cartesian framework, time is something completely extra to the object and its location in space. The three figures look exactly alike. Unless we somehow get the external measure of time, the diagrams give us no information about the object's temporal location. The temporal dimension, be it substantial, space-independent Newtonian equal flow or the ticking of a watch—or any measure that yields $t_1$, $t_2$, $t_3$—is somehow compared to the object's spatial location. This is different from a four-dimensionalist, special relativistic flat spacetime. In the relativistic framework, the worldline represents the particle's positions in spacetime. This is more hospitable to the idea that objects have temporal parts along their worldlines. Imaging four-dimensional space is possible,[2] but we hardly intuit a four-dimensional spacetime. We have to rely on Hermann Minkowski's (1923: 84) idea of a spacetime diagram as depicted on Figure 6.2.

In the spacetime figure, the temporal dimension is in the picture. The object has parts in spacetime. One may certainly conceive of Newtonian spacetime in which the temporal dimension lines up with the *z*-axis. This enables one to draw parallel Euclidian hyperplanes: all and only the points that lie on the same plane are simultaneous (Balashov 2010: 44). In this sense, the temporal dimension is a part of the Newtonian spacetime. It is, however, clear that the Newtonian position draws a

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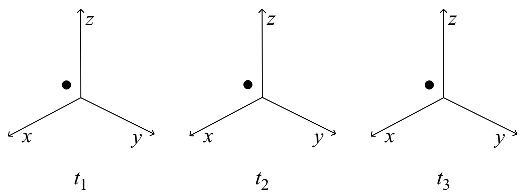


*Figure 6.1* The position of an object in Cartesian three-dimensional space at $t_1$, $t_2$, and $t_3$. I have drawn this image; it has not been printed before elsewhere.

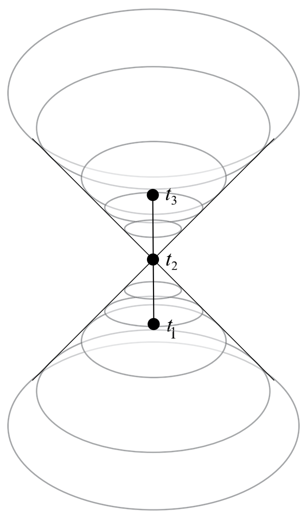


*Figure 6.2* The parts of an object in Minkowski spacetime at $t_1$, $t_2$, and $t_3$. I have drawn this image; it has not been printed before elsewhere.

categorial ontological distinction between space and time. The same does not hold in relativity.

The central idea of this book is, in one way, receptive of moving-spotlight A-theoretic metaphysics: the passage of time is a genuine feature of reality. That approach provides a rather straightforward explanation of how "one and the same thing," Cameron (2015: 152) writes, "exists in its entirety from one moment in time to the next, but nevertheless changes over time." The entity remains the same over time whereas its attributes change over time. Cameron argues that one must be an A-theorist to maintain endurantism.[3] Although I defend the reality of passage, my approach departs from such a metaphysics. I do not think the 'now' changes in an objective way, because the present moment reflects a certain perspective. Analogously, the place 'here' does not change in an objective way, as it is fixed when the perspective or frame of reference is specified. Outside of a perspective, the 'now' has no substantial existence (and outside of a perspective, the 'here' has no substantial existence). The universe does not have its own spotlight of 'now' that moves at a constant rate. As I have explained in the Chapter 1, the rejection of absolute-universal presents leads to, albeit not in any trivial way, eternalism.

I espouse eternalism, so I must admit all my life exists. Everything between my birth and my death is real. No age is, more or less, real than any other age. They exist evenly. This could imply that persons are made of temporal parts. Perhaps a person is an aggregate of various parts of their lifetime. The 'I' might not be an indivisible unitary thing. Rather, what counts as me is made of temporal chunks spread along my timelike wordline. This comes close to perdurantism. In the definition of Lewis (1986a: 202), "something *perdures* iff it persists by having different temporal parts, or stages, at different times, though no part of it is wholly present at more than one time."

There are differences between the older four-dimensionalist perdurantism of Lewis and Quine and the newer stage theory of Katherine Hawley (2001) and Ted Sider (2001). Quine was among the first to consider the relevance of four-dimensionalism to persistence. He thought physical objects themselves are four-dimensional. His account, which is summarized in his philosophical dictionary *Quiddities*, allows change among different parts:

> Change is not thereby repudiated in favor of eternal static reality, as some have supposed. Change is still there, with all its fresh surprises. It is merely incorporated. To speak of a body as changing is to say that its later stages differ from its earlier stages, just as its upper parts differ from its lower parts.
>
> (Quine 1987: 197)

Temporal dimension may not be completely untied from the spatial dimensions, so strictly speaking, parts of time do not stack up. Rather, an object occupies a spacetime region at one time, and then at a later time, it occupies a different spacetime region. "Given relativity," Sider (2001: 82) asserts, "instantiation must be indexed instead to points of spacetime." Balashov (2010: 12–3) explicates:

> The locus of a perduring object is a four-dimensional (4D) region of spacetime which, intuitively, incorporates the object's entire career. A 4D perduring object exactly fits in its spacetime career path and is only partially located at what we normally take to be a region of space at certain moment of time, a three-dimensional (3D) slice of spacetime.

Steven D. Hales and Timothy A. Johnson (2003: 533) argue that endurantism does not fit well with a relativistic world. Their argument shares the same premises of the Rietdijk–Putnam argument. The assumption is that simultaneous events coexist, and that coexistence is transitive. Say $A_1$ and $B_1$ are proper parts of an object at $t_1$ in the object's rest frame. Likewise, $A_2$ and $B_2$ are parts of the same object at $t_2$ in that same frame. $A_1$ and $B_1$ are simultaneous, and $A_2$ and $B_2$ are simultaneous in the rest frame of the object. This implies that $A_1$ and $B_1$ coexist and that $A_2$ and $B_2$ coexist within that frame of reference. In another inertial frame, moving with respect to the former frame, the simultaneous coexisting parts could be $A_1$ and $B_2$. In Hales and Johnson's example, $A_1$ and $B_1$ are equally real as measured in one frame, and $A_1$ and $B_2$ are equally real as measured in the other. Therefore, in reference to the Rietdijk–Putnam type of argument, $B_1$ and $B_2$ must also be equally real. Provided that $B_1$ and $B_2$ are equally real, the earlier parts of an object are as real as its later parts. Moreover, an observer moving with respect to the rest frame in which $A_1$ and $B_1$ coexist/$A_2$ and $B_2$ coexist, the moving observer could conclude that the object is composed of $A_1$ and $B_2$. An observer moving in the opposite direction could conclude that the object's properties are $A_2$ and $B_1$.

On the perdurantist view of objects, different observers see[4] different set of temporal parts, different time slices of them. For an observer in the rest frame, the time slice is perpendicular to the time axis, whereas for the observer moving with respect to the train, the time slice is oblique (Hales and Johnson 2003: 536). Incorporating endurantism into relativity has the peculiar consequence of multiplying objects.[5] On the endurantist view, the parts of an object are wholly present at any given time. If the existence of parts is a frame-relative matter, there will be as many objects as there are relative velocities. It could be that there is an object with parts $A_1$ and $B_2$ wholly present for one observer, an object with parts $A_1$ and $B_1$ wholly present for another observer, and an object with parts $A_2$ and $B_1$ wholly present for a third observer. If endurantism implies that, in the formulation of Hawley (2020: 27), "things are wholly present whenever they exist," there should be as many things as there are present moments. Perdurantism does not face the same issue. There is one object that is composed of parts of various times. The simultaneity of temporal parts is frame-relative, but the existence of one perduring object with parts at different times is not (Hales and Johnson 2003: 538).

When it comes to the notion of change, it is unclear whether an A-theoretic endurantist account has the edge over its B-theoretic rival. M. Joshua Mozersky (2014: 110) presents the difficulty of change for the A-theorist. In general, change requires both difference and identity. When $a$ changes from $F$ to $\neg F$, $a$ will not be entirely the same as before the change. Yet even after the change $a$ should be both $F$ and $\neg F$. $F$ and $\neg F$ are not the properties of a different object; otherwise, nothing would have undergone change. The A-predicates involve a similar kind of problem. The same event *e* must be both *F* (present) and ¬*F* (past or future). This incoherence in the supposed change of A-properties was already noted by McTaggart (and perhaps by Parmenides).

To argue for a B-theoretic notion of change, Mozersky first contrasts his position with Lewis's distinction between intrinsic and extrinsic properties. In the words of Lewis (1983: 197),

> [t]The intrinsic properties of something depend only on that thing; whereas the extrinsic properties of something may depend, wholly or partly, on something else. If something has an intrinsic property, then so does any perfect duplicate of that thing; whereas duplicates situated in different surroundings will differ in their extrinsic properties.

Mozersky remarks that the first sentence of the quote is wrong. A material object occupies spacetime. Mozersky (2014: 115) accepts that an object has intrinsic properties, but it "is material only if it instantiates its predicates at some time (place) or another and this will be true of both an object and its duplicate." An object being red, for example, does not depend on what specific time it is red. It could be red at many times. But in order for there to be a red object, the object and its property must occur at some time (place). The object is red at a time means that it is read in relation to a specific time (place).

The object's relation to different times enables one to articulate the passage of time in terms of the change among object's relations to different times. There is one thing, a process, or a set of events in relation to $t_1$. Then there is change compared to a later time $t_2$: the thing, process, or set of events are to some degree different compared to the earlier time. Mozersky sides with Paul Horwich in explaining how this account of change does not face the same difficulty as the incoherent change in A-predicates:

> The tenseless, B-theoretic world-view is one in which the sum total of events, objects, and processes is unchanging.
>
> (Mozersky 2014: 119)

> [C]hange is always variation in one thing with respect to another, the totality of absolute facts about those functional relations remaining forever constant.
>
> (Horwich 1987: 25)

Even though everything in the block universe exists *simpliciter*, and the totality of what exists does not change, there is change between different times within the block. Earlier in this book, I have concurred with the metaphor that we are passively taken to later times. Mozersky (2014: 120–1) observes how

> our language is perhaps a bit misleading here. We speak of *the* passage of *time* as though some single, individuated entity, Time Itself, is changing or moving, when in fact what is really going on is that changes occur *within* or *with respect to* time. So, "the passage of time" strikes me as a *summary concept* that refers to the ongoing processes of change that constantly occur, in order, with respect to time.

For the relational theory of the passage of time, change does not occur within time, because relationism does not accept the substantivalist notion of time. No being is in time (substantivalism), but beings are temporally related (relationism). Passage occurs between different temporal locations, or to put the point in four-dimensionalist terms, passage takes place among different spatiotemporal locations along worldlines.

The contents of temporal locations are typically described by some events or objects. The relation between the two is relevant for the debate on persistence. In the second version of his *Real Time*, Mellor, although a B-theoretic eternalist, formulates a theory of change consistent with endurantism.[6] "If $a$ is a thing," Mellor (1998: 90) specifies, "it has no temporal parts to take over its properties $F$ and $F'$. They are properties of $a$ itself at different times." Therefore, when $a$ is a thing, $F(a,t)$ and $F'(a,t')$. $F$ and $F'$ are properties of an individual thing, $a$, in which the difference between $a$ is $F$ at $t$ and $a$ is $F'$ at $t'$ is change. That is, the permanent thing, $a$, changes by having different properties, $F$ and $F'$, at different times, $t$ and $t'$. Mellor (1998: 91–2) hence criticizes the typical B-theorist account, which rather denies "any real distinction between things and events, and hence the reality and temporal nature of change."

An essential detail in Mellor's account is the sharp distinction between things and events. It is interesting to note that Quine (1960: 171) already criticized such a strict distinction:

> The space-time view helps one appreciate that there is no reason why my first and fifth decades should not, like my head and feat, count as parts of the same man, however dissimilar.... Physical objects, conceived thus four-dimensionally in space-time, are not to be distinguished from events or, in the concrete sense, processes.

Mellor's (1998) book relies partly on the notion of spacetime, but he does not consider Quine's claim about the four-dimensionality of physical objects themselves. In the view of Mellor, things, not events, change. Things might be countries, companies, humans, animals, and plants, as well as nonliving beings like molecules and galaxies. Events are unchangeable: birthday parties, elections, dinners, speeches, collisions, and so on

(Mellor 1998: 85). Classifying events as unchangeable is understandable from the four-dimensionalist eternalist point of view, as events are spread across spacetime. Both things and events have spatial parts. The way Mellor explains their difference is that things lack temporal parts.

His (Mellor 1998: 86) example concerns the first official ascent of Mount Everest. Edmund Hillary and Tenzing Norgay succeeded in their ascent in 1953. The whole two climbers went up the whole mountain. It is not the case that Hillary and Norgay are made of temporal parts. If this were true, it would imply that some part of them is at the peak, some part of them is climbing, and some part of them is at the base camp. The conquering of Everest is an interesting example, since Mellor would call it an event. The ascent is made of temporal parts. The climbers should not be made of temporal parts, as they should be unitary beings that have incompatible properties at different times. Properties being-excited-and-apprehensive-at-the-start is incompatible with being-tired-and-desperate-at-the-middle, which, in turn, is incompatible with being-relieved-and-proud-at-the-top. The things, that is, the climbers, remain the same at different times. What changes are their properties.

The event of ascending Mount Everest BE tenselessly: there is no way of somehow undoing it. It BE as it BE. We may still imagine an alternative. In an alternative scenario, Hillary and Norgay, at some point in their climb, both hit their heads hard. The ensuing brain damage weakens their memory considerably. They have no clear past recollections. They have no idea where they are. In this hypothetical scenario, we may only surmise what they would do. It is certainly possible that they would not go on and continue their expedition. To understand that they pursue the ascent, they must be able to relate to some part in their past. In B-theoretic terms, they must be able to relate to an earlier part of themselves

Fazekas leans on the centrality of memory to explain the metaphors we apply on moving to later times.[7] In case we lose our ability to form short-term memories, we would be in a very awkward position: Why are we here at this moment, and how did we get here? "The formation of short-term memories," Fazekas (2019: 167) argues, "is a necessary factor in our experience of continuously advancing to later times, because it connects the experience we are having at one time with the experiences we just had at previous times." Forming new memories produces the feeling of having come from earlier times or having moved into later times.

There is an important clarification that should be made. This clarification makes the perdurantist theory less weird. One could confusingly describe the perdurantist position by using the notions of 'still' and 'already.' At the time the two climbers are at the peak, an observer sharing the same spacetime location as the climbers on the peak could say, "According to perdurantism, they are still climbing." At the time the two are at the midway, an observer sharing the same spacetime location as the climbers at the midway could say, "According to perdurantism, they are already at the peak." These descriptions are spurious. The perdurantist claims that all temporal parts exist. When someone arrives at a city by driving from a town to the city, the beginning of the road exists. We do not need to add that the part of the road near the starting point 'still' exists. Likewise, when the driver starts off the engine at the beginning of the journey, we do not need to point out that the part of the road close to the city 'already' exists. The underlying assumption is that the thing in question is constituted of nonidentical temporal parts as well as spatial parts.

Since much of Mellor's later theory of change depends on the distinction between things (which is the same as objects) and events, something should be said about their difference. Table 6.1 is a customary list of the differences (Casati and Varzi 2020).

In my analysis, I wish to focus on the temporal aspects of the distinction. Although the overall distinction seems correct to me, the "relation to time" row is questionable. To start from events, why should we think they have strict temporal boundaries? Real physical events, unlike infinitesimal points used in spacetime diagrams, have some durations, some intervals. When does an event begin, and when does it end? Say the event is a kid's birthday party. It takes place between noon and 2 p.m. on Saturday. How do we define exactly when the event commences and stops? Before Saturday noon, all sorts of preparations take place: writing invitation cards, preparing the cake, and so on. After 2 p.m., some guests might be present, the leftover cake is in the fridge, and the kid plays with their new toys. Physical events are vague because we cannot denote their beginning and their end with point events. We must resort to additional physical events: an event begins and ends with events that lack strictly definable durations (Ben-Yami 2019: 1358).

Why should we conceive of things' temporal boundaries in a different way? Unlike how Table 6.1 propounds, one could equally think that a material being has crisp temporal boundaries. Any view that treats things as underlying permanent entities would claim this. Aristotelian metaphysics refers to substances. Things are individual substances that have different attributes at different times. Things endure over time. This is

*Table 6.1* Differences between things and events

| *Difference* | *Objects* | *Events* |
|---|---|---|
| Mode of being | Exist | Occur, happen, take place |
| Relation to space | Crisp spatial boundaries | Vague spatial boundaries |
| Relation to time | Vague temporal boundaries | Crisp temporal boundaries |
| Location in space | Invidious location | Co-location |
| Movement | Yes | No |
| Persistence | Through time | Parts at different times |

reminiscent of three-dimensionalism: things are in space, and completely external to the place it occupies, time goes on. Where do we get this space-independent flow of time? We might get it from Newton, but his overall position on time is obsolete. Russell (1927: 286) already pointed out that "the old notion of substance had a certain appropriateness so long as we could believe in one cosmic time." Another option, updated to fit Einstein and beyond, is to refer to the laws of nature and the direction of time as ultimate, unanalyzable primitives. This is a plausible strategy. It is not the strategy of this book, as it retains substantivalism about time and the governing conception of laws.

For the perdurantist, passage may be identified in the succession of temporal parts. Passage is, in the deflationary framework, one thing coming after another. If things are made of temporal parts that come one after another, there can be passage despite objects perdure rather than endure. One thing coming after another is change. An object stands in a relation to an earlier time; then, at a later time, it stands in a relation to a different time. The different parts of the object exist, and both the earlier and the later times exist. In between them there is change. Note here the difference between spatial and temporal dimensions. Spatial dimensions are static because spatial extension does not involve change. This is not so for time. Change in temporal dimension is dynamic as temporal extension is the succession of events.

## Notes

1 Huggett and Wütrich (2013) have edited a special issue on the topic. There is also the forthcoming edition by Huggett, Le Bihan and Wütrich.
2 For a method of exposing four-dimensional space, see Norton's website: http://www.pitt.edu/~jdnorton/teaching/HPS_0410/chapters/four_dimensions/index.html. Date of consultation February 7, 2022.
3 Hakkarainen and Keinänen (2010) disagree. They assume eternalism and the B-theory but argue for persistence in virtue of diachronically identical nuclear tropes of simple substances.
4 This is a heuristic device: the temporal order of events is not dependent on receiving electromagnetic signals.
5 The logic of Hayles and Johnson is criticized, among others, by Balashov (2010: Section 5.4). Miller (2004) also criticized Hayles and Johnson. In turn, Harrington (2005) thinks Miller's criticism is based on an erroneous understanding of relativistic concepts.
6 Gonzalo Rodriguez-Pereyra (2003) details how Mellor's views have changed in this regard. Mellor held a theory of relational change in 1981, in the first edition of his *Real Time*. Then he went on to change his position and criticized it in the subsequent edition, *Real Time II* (1998). According to relational change, a leaf is one thing, green, with respect to time $t_1$. A leaf is another thing, yellow, with respect to a later time $t_2$. A leaf is yet another thing, brown, with respect to a later time $t_3$. Properties that change are relations among things and times. A leaf bears the relation 'green-at' to a time $t_1$. After $t_1$, the leaf bears the relation 'yellow-at' to a time $t_2$. After $t_2$, the leaf bears the relation 'brown-at' to a time $t_3$. The leaf may not be green, yellow,

and brown at the same time. It is green, yellow, and brown at different times. The relata between the things and the times are different in each sequence of the object's history (Rodriguez-Pereyra 2003: 185). In the main body of the text, I shall concentrate on Mellor's later view.

7 Memory is also central to the persistence of personhood. There are great many factors that are responsible for the generation of the sense of selfhood from the physical-chemical-biological to the cultural-linguistic. As Marya Schechtman (2014: 139) points out, human lives are so complicated and multifaceted that it is hopeless to produce a single list of necessary and sufficient conditions for the continuity of a person. One extremely important factor to mention is memory (for an empirically inclined article on the relation between memory and personal identity, see Klein and Nichols [2012]). I exist as I can relate my present sense of self to different times. In case my memory would deteriorate considerably, I could not identify myself as the person I have been in the past. This would dramatically change my anticipation of the future, as I could not coherently think of myself as extended in time. For the perdurantist, we are made of temporal parts that are, in some way, connected. This connection is not brought by an underlying enduring self. If our memory is significantly weakened, we lose part of our introspective agency. But this does nothing to the existence of different temporal parts: they are events spread across personalness spacetime.

# Final thoughts

In his *Discourse*, Descartes went on to doubt everything he could. This piece of the history of philosophy is so well known that there is no reason to recount it thoroughly. One curious detail is that Descartes's methodological skepticism included the mind-external bodies. Considering Cartesian physics and metaphysics, bodies are roughly equated with extension and hence with space. In other words, Descartes could doubt the existence of space. Jan Forsman (2021) has shown that Descartes's skepticism was serious. He rigorously questioned what could be questioned. But it did not cross his mind to doubt the existence of time. Even while doubting or dreaming, time marches on.[1]

This book started at the commonsensical point: time passes. Our mundane experience of change and sequence of events is evidence of this. Various metaphysical considerations back up the reality of passage. It is neither irreal nor illusory. As I argued, I think we do not experience passage in the sense that the future approaches, becomes the present moment, and then drifts off into the past. I also argued that such passage does not exist; there is no time itself that undergoes change. The main argument of this book propounds that passage is a relational temporal phenomenon. Over and above the succession of events, there is no time that independently flows. Causation is an asymmetric relation: the direction of time aligns with the temporal order of cause and effect. All of this fits with the four-dimensional block view. The four-dimensional world contains dynamicity. Time path belongs to spacetime. The succession of events along observers' timelike worldlines is objectively, although not uniquely, ordered. One thing comes after another. The totality of what exists remains the same, but there is change between local parts of spacetime regions between an earlier and a later time.

What about fundamental physics that does away with spacetime or indicates that spacetime is effective? How to explain passage in that context even in a deflationary way? If the B-series and the worldlines disappear from that description, it might indeed be that deep down, time does not pass. This could be thought to imply that there is no passage of time. If we commit to this inference, we cannot however see the

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forest for the trees. If a relatively fundamental level or scale of reality lacks some aspect, it does not imply the unreality of that aspect. Passage requires that temporally ordered events exist. When Mozersky was asked in an interview whether his account of the passage of time is deflationary, he answered yes and went on to insist "that such a minimal account captures everything we need the concept of temporal passage to capture: growth, decay, aging, evolution, motion, etc."[2] I think this response is exactly right. Growing, decaying, aging, evolving, and moving are all very real phenomena. Their common denominator is change. The passage of time is about change. There is change in us and around us.

A mug is once full of hot coffee; later, it is almost empty and lukewarm. A person at one time has long hair; now they do not. A student gets a low grade; then they prep and eventually improve in the re-exam. Time passes.

## Notes

1 Tim Maudlin makes this point in a discussion with Emily Thomas and Julian Barbour on the topic "Does Time Pass?" The discussion was hosted by Joanna Kavenna and brought by The Institute of Art and Ideas: https://iai.tv/video/the-illusion-of-now-is-time-static-or-fluid. Date of consultation: February 2, 2022.

2 Mozersky was interviewed by Richard Marshall at 3:16: https://www.3-16am.co.uk/articles/time-language-ontology. Date of consultation: February 2, 2022.

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