'And Yet It Moves':
The Physics, Metaphysics, and Phenomenology of Time's Passage

by

Emily Jane Rogers

A thesis submitted in partial fulfillment
of the requirements for the Doctor of Philosophy degree
in Philosophy
in the Graduate College
of The University of Iowa

May 2024

Thesis Committee: Katarina Perovic, Thesis Supervisor
Gregory Landini
Kenneth Williford
David Stern
Richard Fumerton

ACKNOWLEDGMENTS

My journey into philosophy really properly began in my senior year of high school. I was going through a very rough patch, and someone – I can't remember who – recommended that I talk to Dr. David Tripp, our high school's philosophy teacher. Although I was not even in his class, he met with me at lunch every week for several months, to talk me through ideas that were troubling me. He gently pointed me in the direction of various pieces of philosophy I might read to help me untangle things. By the time I graduated – by the skin of my teeth – I had already decided that I would pursue philosophy as a major in college. So, there is a real sense in which this project begins with him. Thank you, Dr. Tripp, for providing an intellectual guiding light when I needed it most, and thereby changing the course of the rest of my life.

My undergraduate philosophy professors at the University of Texas at Arlington took over where Dr. Tripp left off. The late Dr. Harry Reeder was the first professor I met in college, and the extent of his influence on me is indicated by the fact that I quoted him to my partner last week while discussing my dissertation project, though it's been close to 20 years since he uttered the sentence in question ("Graphing is lying!"). I also owe particular thanks to Dr. Charles Hermes, not just for teaching an introductory metaphysics course which clearly left some sort of mark, but also for his rather colorful endorsement of me when I came to him unsure whether or not I was grad school material.

I asked a similar question to Dr. Kenneth Williford, another one of my undergrad professors, and he should be thanked profusely for (in the process of answering positively) raking me over the coals about being too quick to dismiss ideas once I'd spotted some flaw in them. His admonition struck me hard: I became much more conscious of the principle of charity after that, and I think it has improved my philosophical ability. Now I owe him additional thanks for over a decade of friendship and music and interesting conversation.

I of course owe thanks to the University of Iowa generally for letting me in at all, and for providing me numerous forms of financial support in the form of fellowships and grants. But I owe more particular thanks to UIowa's Philosophy department, which is really a much better department than I could have possibly anticipated. All of the faculty are world-class thinkers; the department is supportive, inclusive, and has a very congenial open-door atmosphere; its insistence on giving students as much teaching experience as possible has given me some of the most valuable experiences of my life, in front of a classroom. (And, here I should thank my students for those experiences. Almost nothing is quite as enjoyable or instructive as a good day of teaching.)

Thanks to Dr. David Cunning, who was chair for most of my tenure as a grad student; the department flourished under his leadership because of his commitment to advocating for people in positions of less power and his ability to interface with the college as a whole and with the wider community. He advocated for me when I was pregnant and unsure how to manage grad school at the same time; he was the one who convinced me to return after I left the program for a year; and he has never failed to let me know when he thought I had a good comment or question in a Q&A session, which is a kind of small encouragement that helps one keep going when one doubts oneself.

Thanks to Dr. Gregory Landini, whose warmth and humor and creativity made me feel at home and taught me to be willing to embrace whatever positions the arguments drove me into. Often when I have felt puzzled in a way I could not articulate, I simply cleared my schedule, knocked on Greg's door, and asked him a vague question in the vicinity of the topic I was confused about. Two or three hours later, I would inevitably emerge considerably edified. That is to say two things about Greg: he is brilliant, and he is always willing to help.

Thanks to Dr. David Stern, who has an incredible knack for delivering kind words just when I happen to need it most. Under David's guidance I received an Outstanding Teaching Award for teaching an introductory logic course – an award that must begin with nominations from happy students – and lest you think this is just because of my own teaching skills, it's notable that the other grad student teaching the same course that semester, who was also

under David's guidance, also won such an award. This is evidence of David's ability not just to teach, but to teach to teach; not everyone has the former, and the latter is even rarer.

Thanks to Dr. Richard Fumerton, who famously always manages to know his opponents' views better than they know their own — and consequently a great many students at Iowa (myself included) have learned much simply from trying to emulate him. I find myself, when nervous in a professional setting, asking myself what Richard would say or do. He would be relaxed, careful, charitable, precise, and not without humor, of course — a tall order which I do not live up to, but nevertheless am grateful to have had the example.

Unending thanks to my dissertation advisor, Dr. Katarina Perovic, whose patience and encouragement even in my darkest moments kept me chugging along, and whose incredibly careful, thorough mind taught me much about doing philosophy the right way. Katarina is the one who taught me the importance of minding one's presuppositions and not falling for pseudo-problems. And she has gone the extra mile in advocating for me, showing up for me, talking me through problems, and offering me an enormous amount of feedback as I developed the ideas in this dissertation. I have been lucky to have her as both a mentor and a friend.

Thanks to all my fellow grad students who put up with my nonsense and provided me countless hours of entertainment and philosophical grist for the mill. There were many who made a difference to me; particular thanks are due to Dr. Landon D. C. Elkind, Joseph Glover, and Jason Messerschmitt. (You all know what you've done.)

Thanks to the CTSDMC at UIowa, where I have been employed for the last year and a half, and particular thanks to my supervisors Zackary Lemka and Trevis Huff, both of whom have been incredibly supportive of me both personally and professionally and have given me the space to grow.

Thanks to all the babysitters who helped me get through this project, and especially thanks to Cathy Stange and the staff at Little Angels Learning Center, who lovingly watched both of my kids over the course of time, and have more than risen to the task of supporting my youngest's unusual health needs.

I don't know how one even begins to thank one's family, and at any rate, I have such a large family that I could not possibly name them all here. But to my parents, Kimberly and Jay von Tungeln: thank you for *everything* — for all the cheerleading, all the material support, all the phone calls and visits, all the love you put into raising me and getting me here.

Thanks to April Lee for coming along with me on my journey from undergrad, to grad (Linguistics), to grad again (Philosophy), to grad again (re-entering Philosophy), to grad again (Epidemiology), to grad again (Philosophy one last time), and beyond.

Thank you to my kids, Kris and Levon Waddle (both of whom were born during my tenure as a grad student) for lighting up my life like a pair of very busy supernovae. I especially thank Kris for putting up with my being absent or distracted during the last few months of working on my dissertation. I love you both more than you will ever know.

Finally, thanks beyond measure to Dr. Benjamin Slade. I dedicate this work to him, as I could never have finished it without his incredible love and support, his encouragement when the process of writing daunted me, his extensive knowledge of LaTeX, and the many hours of verbal sparring and sprawling conversations on the language of time. "You slid back through my life, and I have known you since before I knew you."

ABSTRACT

The aim of this dissertation is to convince you that *time passes*. It is commonly held that a belief in time's passage is in conflict with relativistic physics and that our phenomenology as of passage is not sufficient reason for us to believe in it. I argue that both of these views are false. Along the way I offer a typology and critique of the existing accounts of passage. I offer my own view of passage, the process view, which requires that we be relationalists about time. I make the case that there is strong reason to endorse relationalism.

In Chapter 1, I outline the most common positions in temporal ontology (presentism, eternalism, growing block theory, and the moving spotlight view), which are each committed to two theses: an ontological thesis about what exists, and a second thesis about whether the world is static or dynamic. I argue that the ontological theses are either trivial, not meaningful, or beg the question. I then try to recast the ontological theses in terms of truthmaking, which I argue also fails to generate a substantive dispute. I ultimately argue that the best way to salvage the debate over temporal ontology is to understand it as a debate about the second theses, that is, about whether or not time passes.

In Chapter 2, I turn to trying to spell out what temporal passage is supposed to be. I give a typology of the existing accounts of passage in the literature, and give some critique of each. I then try to offer my own account of what passage is: passage is to be identified with change, which is to be understood, not as the standard 'at-at change', but in terms of a primitive which I call process. Finally, I note that my account of passage requires relationalism to get off the ground.

In Chapter 3, I ask whether we should be substantivalists or relationalists about time, independent of our views on passage. I begin with an overview of the historical debate, focusing heavily on Newton, Leibniz, and the 20th century turn to considering "spacetime" as one entity (rather than treating space and time as two separate entities). I give an overview

of the ways in which substantivalism and relationalism are characterized in contemporary debate, and show that it is more difficult than it seems at first pass to parse out what substantivalism is supposed to be. I offer three plausible versions of substantivalism, and characterize relationalism as the denial of all three. I then provide a critical discussion of five major arguments for or against substantivalism, and conclude that there is strong reason to accept relationalism.

In Chapter 4, I turn to the question of whether or not we should take our phenomenology as of passage seriously. The dynamic theorist demands an error theory from the static theorist: how is it that we experience temporal passage if there is no such thing? The most common static theorist response to the demand is to say that our experiences as of passage should be considered illusory, either as a cognitive-perceptual illusion akin to illusions of apparent motion, or as a consequence of our (false) view of ourselves as enduring selves against a changing background. I show that these accounts fail because they end up presupposing dynamicity in their quest to show that reality is static, because illusions require dynamicity to get off the ground. I then turn to another common static theorist response to the demand, which is to argue that the phenomenal reality of passage cannot (or should not) tell us anything about the physical reality of passage. One version of this move appeals to the absence of temporal passage in the formulations of the laws of physics; I show that this reasoning relies on an incorrect identification of passage with a privileged property of presentness. Another version argues that because our phenomenology is notoriously subject to a variety of interfering conditions, it is unreliable as a basis for theorizing. I respond that we do not require complete reliability from our evidence in order to use it to build a view, either in science or in philosophy. I conclude that we must take our phenomenology seriously after all, and that it gives us good reason for thinking that temporal passage is a real feature of the world.

In Chapter 5, I summarize the work I have done and try to tie up some loose ends by exploring consequences for ontology in light of the process view. I finish with a discussion of what we should do when science and philosophy seem to conflict.

PUBLIC ABSTRACT

Most people probably think that *time passes*. Philosophers who agree say that our experiences of time passing are proof that time passes. But a lot of other philosophers think that time doesn't pass, because they think that physics tell us that the world contains a four-dimensional spacetime manifold where all past, present, and future events are located, and these events never change.

Passage-deniers think that the universe is really static, and our perception of change is a cognitive illusion. For example, if you make a cartoon flipbook of a boy bouncing a ball, the pages are all unchanging, and yet flipping the pages produces the illusion that the boy is in motion. But I argue that there is no way to generate the illusion from the flipbook without *flipping the pages* — that is, in order to have any illusions at all, there has to be real, dynamic change going on!

I also argue that physics doesn't really tell us that the world is static. Physicists use the concept of the spacetime manifold to mathematically model the world, but that's not the same thing as saying that the spacetime manifold *really* exists.

In general, we should be careful to distinguish our linguistic and mathematical models from the actual world. We say that objects are solid and unchanging, but we know they're really made of particles which are constantly moving and changing. There's no way to separate objects from the processes they consist of. Everything is in process. So, time is passing.

CONTENTS

PREFACE

Time undergirds the discourse in wide swaths of philosophy. After all, what would it mean to talk about causation, free will, personal identity, agency, decision theory, or cognitive processes without reference – explicit or implicit – to time? Yet, though it cuts through so many of our other discussions and debates, we know comparatively little about it. The field of philosophy of time is relatively small, and notoriously fraught with difficulty, even when compared to other areas of philosophy. For instance, two of the most dominant views about time, presentism and eternalism, are caught in an unusual kind of deadlock. Presentism – roughly, the view that only the present exists – is (allegedly) buttressed by that which we know most intimately: our own phenomenology. On the other hand, eternalism – roughly, the view that the past, present, and future are all equally existent – is (allegedly) held up by modern physics. The deadlock between the two positions is unusual because it comes about not just because of a dispute about the arguments, nor just because of a clash of intuitions. Instead, the two sides appear to clash about the weighing of evidence — specifically, about whether evidence from physics or phenomenology should take precedence in metaphysical disputes.

I think that one reasonable move to make when confronted with a deadlock is to question the assumptions that underlie the opposing positions. Some headway has been made in this manner, but not enough. For instance, presentists and eternalists commonly take themselves to be engaged in an ontological dispute: a dispute about what exists. But skeptics have challenged the idea that there is anything substantive at issue between these apparently rival temporal ontologies. These skeptics point to mere linguistic confusion as the source of the difficulty. After all, when the eternalist says, "Socrates exists", and the presentist denies this claim, it's hard to say what exactly is at metaphysical issue between them. Neither one of them would deny that Socrates did exist in the past, and both agree that he does not exist in

the present. This might lead one to think that when the presentist denies "Socrates exists", it's because the presentist is restricting the quantifier to the domain of only present things, while the eternalist includes past (and future) things in the domain of their quantifier. But that would mean the debate is really just a linguistic dispute about how to use the word "exists" — the opposing parties agree on all the facts.

This is a tempting line to take — and I certainly agree that spelling out what is at issue is more difficult that it seems at first glance. However, I disagree that there is nothing substantive at issue between presentists and eternalists. Specifically, I think that the debate between rival positions in the ontology of time really boils down to a dispute about whether time is dynamic or static: that is, whether or not there is any such thing as the passage of time.

This, one might complain, does not help much. Non-believers in passage have pointed to the extraordinary difficulty in spelling out what passage might be, as a reason for disbelieving in it. And it is true that there have been vanishingly few attempts to give an account of temporal passage. So proponents of passage have acknowledged the difficulty, but point to our phenomenology – our experience as of continuous change – as a reason for believing in passage. This is, after all, a ubiquitous feature of our experience which we cannot escape. But non-believers have made three common responses which I will address: first, some of them have responded by interpreting these experiences as of passage as non-veridical — mere illusions, either akin to illusions of apparent motion. Second, some of the non-believers have made the stronger claim that we couldn't possibly experience temporal passage veridically because temporal passage is not required for a complete physical description of the universe, and so, even if it does exist, it must be epiphenomenal to the physical, and thus unable to affect our brains. Third, other nonbelievers have argued that our phenomenology of time, even if it does include passage, should not have any bearing at all on our ontology, because our phenomenology is notoriously unreliable and subject to easy alteration.

I think that these arguments against taking our phenomenology seriously are doomed to failure, for it is impossible to have experiences of any sort unless passage really exists in some

way. The static theorist has the option to avoid saying that temporal passage is a real feature of the physical universe by embracing dualism, and thus acknowledging the real existence of passage, but only phenomenal passage. But if one is not committed to dualism, one should then conclude that temporal passage is a real feature of the physical universe.

However, even if one does accept the reality of temporal passage on the basis of our phenomenology, this drags in yet another problem, one that is also fraught with issues of how to weigh competing sorts of evidence. Consider: if passage is a real feature of the universe – if time genuinely passes – then does that imply that there is an entity, time, which does something, namely, passing? That is, is time an independently-existing entity?

This is what is at stake in the debate between substantivalism (the view that time is ontologically independent from material bodies) and relationalism (the view that time is derivative from material bodies and their relations). As we shall see, contemporary physics of spacetime was born out of a desire to avoid substantivalism, on the part of Mach and then later Einstein. But Einstein's Special and General Theories of Relativity both invoke spacetime in their formulations. In the General Theory, spacetime is understood as dependent on the distribution of matter in the universe and so does not require substantivalism. But the General Theory collapses to the Special Theory in situations with very little gravity (such as near-empty worlds) and the Minkowski spacetime of Special Relativity is not obviously dependent on the distribution of matter. So many people think that we ought to be spacetime substantivalists in order to account for certain situations which can only be described using Special Relativity. But still others think that we ought to embrace relationalism because substantivalism commits us to an entity (the spacetime manifold) which is unobservable even in principle. This, in turn, commits us further to saying that there could be multiple configurations of the universe which were different only with respect to their spacetime manifold and so no observer would be able to tell any difference between them. So substantivalism asks us to accept the existence of an unobservable entity because the physics (seems to) require it; relationalism tells us that substantivalism undermines the determining power of that very same physics.

And we need to sort out which is worse. For the substantivalism-relationalism debate is rarely discussed in the temporal ontology debate (and vice versa), but the two are deeply linked. Theories of time are often cast in apparently relationalist terms: the A-theory is the view that time consists of the monadic properties being past, being present, and being future, while the B-theory is the view that time consists of the relations being earlier than, being simultaneous with, and being later than. Yet a great deal of the literature also talks, implicitly or explicitly, in substantivalist ways. For instance, many freely talk about instants, temporal "slices", moments, and the like. This talk seems to come from the treatment of spacetime points as independently existing entities. If substantivalism is false, then the notion of an instant (or a spacetime point) is suspect at best: on a relationalist view, time is nothing more than change, and no change can happen at a durationless instant. But if substantivalism is true, then it's hard to see how we could still embrace either the A-theory or the B-theory: time will be something over and above their defining properties. So there seems to be a deep confusion in the way time is approached, on all sides.

I began the process of writing this dissertation with the central idea that it made no sense to explain the appearance of dynamic change with an appeal to a static universe. As my research progressed, I found paper after paper repeatedly running into the kinds of deadlocks and confusions which I've described above. I grew determined to try to sort out some of this confusion. Along the way, I became ever more convinced that *time passes*, not just in our minds, but in the physical world. This dissertation aims to convince you of the same. To that end, it will have the following structure:

In Chapter 1, I outline the most common positions in temporal ontology (presentism, eternalism, growing block theory, and the moving spotlight view), which are each committed to two theses: an ontological thesis about what exists, and a second thesis about whether the world is static or dynamic. I then turn to a skeptical challenge to the ontological theses: the argument that a sentence like "Socrates exists" can only be made into the object of a substantive dispute about temporal ontology if the "exists" being employed means "exists *simpliciter*" or "exists tenselessly". I argue that these formulations are either not meaningful

or beg the question. I then try to recast the ontological theses in terms of truthmaking, which also fails to generate a substantial dispute, because either neither side can help themselves to truthmakers from the past, or both can. I ultimately argue that the best way to salvage the debate over temporal ontology is to understand it as a debate about whether or not time passes.

In Chapter 2, I turn to trying to spell out what temporal passage is supposed to be, discussing different notions that have been offered. I question when having primitives in one's ontology is acceptable, and when it is merely an attempt to skirt the work of explanation. I give a typology of the existing accounts of passage in the literature, and give some critique of each. I then try to offer my own account of what passage is: passage is to be identified with change, which is to be understood, not as the standard 'at-at change', but in terms of a primitive which I call process. Finally, I note that my account of passage requires relationalism to get off the ground.

In Chapter 3, I ask whether we should be substantivalists or relationalists about time, independent of our views on passage. I begin with an overview of the historical debate, focusing heavily on Newton, Leibniz, and the 20th century turn to considering "spacetime" as one entity (rather than treating space and time as two separate entities). I give an overview of the ways in which substantivalism and relationalism are characterized in contemporary debate, and show that it is more difficult than it seems at first pass to parse out what substantivalism is supposed to be. I offer three plausible versions of substantivalism, and characterize relationalism as the denial of all three. I then provide a critical discussion of five major arguments for or against substantivalism, and conclude that there is strong reason to accept relationalism.

In Chapter 4, I turn to the question of whether or not we should take our phenomenology as of passage seriously. The dynamic theorist demands an error theory from the static theorist: how is it that we experience temporal passage if there is no such thing? The most common static theorist response to the demand is to say that our experiences as of passage should be considered illusory, either as a cognitive-perceptual illusion akin to illusions of ap-

parent motion, or as a consequence of our (false) view of ourselves as enduring selves against a changing background. I show that these accounts fail because they end up presupposing dynamicity in their quest to show that reality is static, because illusions require dynamicity to get off the ground. I then turn to another common static theorist response to the demand, which is to argue that the phenomenal reality of passage cannot (or should not) tell us anything about the physical reality of passage. One version of this move appeals to the absence of temporal passage in the formulations of the laws of physics and concludes that temporal passage must be epiphenomenal. I show that this reasoning relies on an incorrect identification of passage with a privileged property of presentness. Another version argues that because our phenomenology is notoriously subject to a variety of interfering conditions, it is therefore unreliable as a basis for theorizing. I respond that we do not require complete reliability from our evidence in order to use it to build a view, either in science or in philosophy.

In Chapter 5, I summarize the work I have done and try to tie up some loose ends by exploring consequences for ontology in light of the process view. I finish with a discussion of what we should do when science and philosophy seem to conflict.

Chapter 1

ON THE LANGUAGE AND ONTOLOGIES OF TIME

> "...[I]t seems to me that the most fundamental question in the philosophy of time is whether a static or dynamic conception of the world is correct." (Tooley, 1997)

1.1 Introduction

One of the central disputes in the philosophy of time is about temporal ontology. Temporal ontology is the study of "what there is" with respect to time. People who do temporal ontology typically concern themselves with questions like, "Do only present things exist? Or do past things exist as well? What about future things?" The four most dominant temporal ontologies are known as presentism (the view that only present things exist), eternalism (the view that past, present, and future things all exist), growing block theory (the view that past and present things exist but future things do not), and the moving spotlight view (the view that past, present, and future things all exist, but there is also a privileged, ever-changing present).[1] People with competing temporal ontologies usually take themselves to be disagreeing about things like whether or not Socrates, the 50th president of the United States, or their own infant selves exist. But there are skeptics about temporal ontology who question whether any substantive metaphysical dispute is actually to be had between these apparently rival views. They typically problematize disputes about whether or not, e.g., "Socrates exists" by pointing out that on one reading ("Socrates exists now"), everyone in the debate would agree that he does not exist, and on another reading ("Socrates exists in such-and-such a year [in his lifetime]"), everyone in the debate would agree that he does. They worry that each side is just taking their preferred reading of the sentence, and that this

[1] These are intended to be rough characterizations of the views as they are usually stated, and they will be fleshed out later in the chapter. In particular, they should not be taken as my endorsement of existence as a genuine property.

makes the entire debate, and (given its centrality) perhaps the entire field of philosophy of time, collapse into nothing but mere linguistic quibbling about how to use the word "exists".[2]

It certainly seems like it is both intelligible and of metaphysical import to disagree about whether or not Socrates exists. But it is hard to spell out what exactly that disagreement consists in. If all we are doing is talking past one another by using "exists" in a different way than our opponent, then a dispute about whether "Socrates exists" really just amounts to p vs q. A substantive dispute should take the form p vs $\sim p$; there should be something that one party asserts that the other denies. The big question, then, is whether the skeptics are right. Is there any substantive metaphysical dispute to be had between rival temporal ontologies? In this chapter, I aim to show that there is.

I begin (in section 1.2) by discussing how to characterize the dominant views in temporal ontology, borrowing heavily from Kristie Miller (2013) for the initial characterizations. Then, in section 1.3, I raise problems with the characterization of these views in terms of what exists, and show that doing so cannot generate the genuine debate we are looking for: existence is not a genuine property, and so attempts to generate a substantive dispute using characterizations that involve an existence predicate are doomed to failure. In section 1.4, I turn to attempts to frame the debate in terms of truthmaking, and show how that also fails to generate a substantial debate. In section 1.5, I briefly point to a general lesson that might be drawn from the difficulty of doing ontology in terms of existence claims. Finally, in section 1.6, I argue that the best way forward is to understand the heart of the debate as being about temporal passage.

1.2 An inventory of contemporary temporal ontologies

Before we can begin to decide whether any substantial metaphysical disagreement exists between apparently rival temporal ontologies, we must know what those temporal ontologies are (or purport to be). For the purposes of this dissertation, I will address the four most

[2]For examples of such skeptics, see Dorato (2006) and Savitt (2006).

common temporal ontologies, listed in rough order of their current popularity (as far as I can tell): eternalism, presentism, growing block theory, and the moving spotlight view.[3] In what follows, I will discuss the characterization of each.

1.2.1 Eternalism

Eternalism, which is perhaps the dominant view in philosophy, has usually been characterized as the view that the past, present, and future all exist and are ontologically on a par with each other. To give some examples of such characterizations, we are told that eternalism is the view that "the past, the present, and future are all real" (Callender 2011), that "all moments of time and their contents enjoy the same ontological status" (Balashov 2011), that "past, present, and future are equally real" (Petersen 2015), that "all times and/or events exist" (Deng 2018), or even that that "past, present, and future entities exist *simpliciter*" (Bihan 2020).

However, these simple characterizations are not enough to distinguish eternalism from the moving spotlight view, since both views are committed to the existence of the past, present, and future (but the moving spotlight features a privileged, ever-changing present). It would be nice, therefore, to have a more robust characterization of eternalism.

One good candidate is that from Romero (2015), who gives us an expanded version of eternalism he calls Block Universe (BU):

> Past, present, and future moments (and hence events) exist. They form a 4-dimensional 'block' of spacetime. Events are ordered by relations of earlier than, later than, or simultaneous with, one another. The relations among events are unchanging. Actually, they cannot change since time is one of the dimensions of the block.

Such a view builds in not just the commitment to past and future entities but also what sorts of relations those entities can stand in and whether those entities can change. And despite

[3] I think it worth noting here that these four are not just "the four most common views", but are so dominant as to represent nearly the entirety of the inventory of temporal ontologies that philosophers hold.

all these extra commitments, this is a rather common contemporary version of eternalism; the "block universe" is a topic of frequent discussion in the literature.

But, strictly speaking, this too does not technically distinguish between eternalism and the moving spotlight view, since both can hold that spacetime forms a block and that the relations between events are unchanging. Ergo, let us consider one more expanded characterization which offers more promise in making the right distinctions. This is the characterization from Kristie Miller's 2013 "Presentism, Eternalism, and the Growing Block". Eternalism is characterized by Miller as the endorsement of both of the following:

1. EOT (Eternalist Ontological Thesis): Past, present, and future times exist.

2. ST (Static Thesis): The present does not move: which moment is the present moment does not change.

That is, the world (as a whole) is static. Nothing comes into being or passes away. 1947 and 2047 are equally as real as the current year. 21-year-old Socrates is still "out there" — he's just located in his own portion of spacetime, which is inaccessible from ours.[4,5] The phrase "the present" does not pick out a metaphysically weighty feature of the world; it's no more than an indexical, dependent for its meaning on the context of its utterance. 21-year-old Socrates has his "present", as we have ours. Since the present is not an absolute (non-relative) feature of the universe, it does not move or change in any absolute sense.

Note that it's the second thesis here which does the work of distinguishing eternalism from the moving spotlight view, according to which there is a changing, metaphysically privileged present.

Eternalism's advocates generally endorse it because it (appears to) accord with the best current physics, particularly Special Relativity, which tells us that there is no privileged

[4]At least currently. Those who believe that time travel is theoretically possible will probably think of this inaccessibility as a barrier which may be possible to cross with the right advancements in technology.

[5]It is also technically possible, at least given how Miller has characterized eternalism here, that one could be an eternalist who holds that the past is real but "empty" — that is, you could be a substantivalist about past times but hold that Socrates doesn't exist anymore to occupy those times. No one I know of holds such a view, but I thought the possibility worth mentioning.

reference frame and therefore is often interpreted as telling us that there is no privileged, global present.[6] Instead, from one particular reference frame, some event e may be present, but from another reference frame, e may be past, and there is no non-arbitrary way to designate a particular reference frame as the "correct" or "real" one. Accordingly, it is thought, e must be just as real as any other event, regardless of whether it is past, present, or future in our own reference frame. And so on for all other events.

Eternalism's detractors generally reject it because it does not accord with our phenomenology, which seems to tell us that there is a privileged present, and that time is genuinely passing: that is, events do not appear to us to be static and unchanging in their relations, but to take place (and cease to take place) in some way that is not captured by a static block universe model.

1.2.2 Presentism

Against eternalism, we have its most dominant rival, presentism. Presentism is sometimes thought of as the "common sense" view, or the layman's view, according to which all that exists is what exists *now*. To take some examples of its characterization, we're told it's the view that "only the present and/or present things exist" (Deng 2018), that "only present objects exist" (Markosian 2004), that "all and only present things exist" (Pezet 2020), that "the present is ontologically privileged" (Petersen 2016), that "only those events that take place in the present are real" (Romero 2015), and that "present entities possess the ontological privilege of existence: past and future entities do not exist *simpliciter*" (Le Bihan 2020).

But just as we saw with eternalism in the previous section, these typical characterizations (which are focused solely on the question of what exists) miss something that is crucial to

[6]But, as Gregory Landini correctly pointed out to me, and which I will mention again in Ch.5, it's not that Special Relativity tells us directly that there is no privileged present. Special Relativity does not make claims about what exists or doesn't. Instead, it would be better to say that the idea of a global (privileged) present is meaningless under Special Relativity, since simultaneity will always be relative to one's choice of reference frame. But this also means that any *absolute* notion of 'being past' or 'being future' is meaningless. There is only an event's being past with respect to another event in a particular reference frame. Consequently, usages of 'past', 'present', and 'future' are necessarily indexical for eternalists. (I am not sure whether indexicals pick out properties of any sort; I will not take a stance here.)

the view. For, on these characterizations, one could be committed to the view that all that exists is the present, without being committed to the view that anything changes at all: there could be a static and eternal now. It would be a very odd view, to be sure, but nothing in presentism's typical characterization rules it out. (And, in fact, according to eternalism, something kind of like this *is* true of *now*: *now* is static and unchanging, "frozen" (so to speak); just as each moment in the spatiotemporal block must be. It is only the fact that the next *now*, and the next *now* after that, etc. differ slightly from each other from which we must derive our illusion of any sort of dynamicity.)

So for the sake of more accurately capturing what presentists actually believe, I rely again on Miller (2013). As Miller characterizes Presentism, it is committed to the following two theses:

3. POT (Presentist Ontological Thesis): Only the present moment exists.

4. DT (Dynamical Thesis): The present moves: which moment is the present moment changes.

That is, she says, only present things exist; a different set of events comes into existence and passes away, as each new present moment comes into existence and passes away. This means that, mercifully, your awkward junior high self is not "out there" eternally living out some horrible chaperoned school dance. Neither is Socrates wandering the Agora, nor is next year's Super Bowl winner celebrating their victory. There is only what is happening *now* – *now* – and *now*. The event of you reading the last sentence is gone; only the event of you reading this sentence remains, and that only for as long as it lasts.

Obviously there are many questions raised by such a view. How long does the present moment last? Is it present times or objects or entities or events that we should be counting when we take our ontological inventory? And so on. The answers to these will depend on one's version of presentism. But for now, the work is only to get a good working characterization of the views.

Presentism's endorsers are generally attracted to it because it appears to accord with our experience of the world: the past is gone, and the future hasn't happened yet. They think that all that we can observe is what we observe now, and the simplest explanation of this fact is that now is all there is.

Presentism's detractors often complain that presentism does not appear to accord with Special Relativity, and moreover that presentism cannot explain what the truthmakers would be for truths about the past: if objects in the past no longer exist, then it seems they cannot stand in relations. But then what makes it true that Caesar crossed the Rubicon, if Caesar no longer exists?

1.2.3 Growing Block Theory

Growing block theory is relatively less well-known compared to presentism and eternalism, but its popularity has been lately increasing. It is often seen as a "middle way" view that takes the best of both eternalism and presentism (and, according to its detractors, also inherits both views' deficiencies). Writers on the growing block theory are fewer; but it arguably starts with C.D. Broad (1923), while Tooley (1997), Briggs & Forbes (2017), Correia & Rosenkranz (2018), and Perovic (2019) have all done noteworthy recent work. But precisely because it is less often written about, and there is therefore less in the way of standard characterizations, I'll skip the recap this time, and go directly to Miller's version instead.

Growing block theory is characterized by Miller as the endorsement of the Dynamical Thesis (DT) (discussed in the section on presentism), plus the following:

5. GBOT (Growing Block Ontological Thesis): Past and present moments exist, but future moments and events do not exist.

So, for the growing blockist, the universe can be thought of as a block of spacetime, just like for many versions of eternalism. This block contains all the past events, but unlike eternalism, the future does not exist and is not part of the block. Instead, the edge of the block is the present moment. That edge is dynamic; it changes as the present changes, by

constantly adding more "slices" of reality to the block, as each present moment becomes past. This constantly expands the set of things that exists. On this view, Socrates is "out there", but the 2026 midterm election results are not.

Growing blockists are generally attracted to the view because it both offers truthmakers for past truths (since the past remains real), does not force us to take a stance on causal determinism (since the future is "open"), and accords with our experience that there is a privileged, changing present.

People who are opposed to growing block theory often complain (as mentioned previously) that the theory inherits the faults of both presentism and eternalism: it privileges a present which is not found in Special Relativity and it also manages to reify the past in a way that does not accord with experience. Moreover, some authors (see, for instance, Braddon-Mitchell 2004, Forrest 2004, Forbes 2016) have raised the concern that on the Growing Block View, when one refers to something happening 'now' (in the indexical sense), one cannot know whether one's utterance is really happening 'now' (that is, simultaneous with the privileged present located at the growing edge of the block).

1.2.4 The Moving Spotlight View

The moving spotlight view is less often endorsed compared to the other three views, but is still well-known enough to warrant discussion. Its most notable proponent is Cameron (2015), but Deasy (2015) and Miller (2019) have also contributed interesting work on it. As with Growing Block Theory, the lack of enough work to count as "standard" means I will skip straight to the characterization from Miller (2013).

Miller characterizes the Moving Spotlight view as the endorsement of both the Eternalist Ontological Thesis (EOT) and the Dynamical Thesis (DT). According to this view, reality is a large spacetime block containing all the past, present, and future events (EOT), but there is an objective, ever-changing present (DT), which is usually conceived of as somehow moving through the block "lighting up" different times — that is, causing them to be metaphysically privileged (by way of having the property of objective presentness). What is present now is,

in fact, present in an absolute sense, but only because this is where the moving property of presentness happens to be right now, as it were. The future is "out there", unchanging but metaphorically awaiting its turn to be lit up, and the past, we might say, is also "out there", unchanging but metaphorically dead, frozen, done.

Defenders of the moving spotlight view generally are pleased with the fact that, like eternalism, it makes all events (past, present, and future) equally real and therefore can offer truthmakers for each time. Moreover, they think, because all times exist on this view, reference frames can be freely selected from without running afoul of Special Relativity. But unlike eternalism, this view has a dynamic component – the spotlight – which they think salvages our phenomenal experiences of a dynamic world.[7]

Opponents of the moving spotlight point out that the privileged present involved in the view seems to be doing no work: since the block universe is still static, nothing changes except for the location of the spotlight itself. This does not seem to map well onto our phenomenal experiences of change which are usually the motivator for views that embrace the Dynamic Thesis: we experience dynamic-seeming events, objects changing over time, and those changes seem to be things that happen to the object, not changes in time alone. As such, it is unclear what the spotlight really buys someone who is not convinced by eternalist arguments.

1.3 Problems with the ontological theses

By my lights, Miller's characterizations of the views that we've discussed are simultaneously fair representations of what their respective view-holders say about their own views, *and* deeply problematic, for a number of reasons. In each of the subsections below, I raise issues with the ontological theses (POT, EOT, and GBOT). In 1.3.1, I first discuss a terminological

[7] One might think that if the Moving Spotlight theorist has a privileged present in the form of the spotlight, then they will still be in tension with Special Relativity because they will have an absolute simultaneity relation. However, this is only the case if they hold that the moving spotlight is a physical feature of the world. If they were to embrace dualism, they could hold that the moving spotlight is a purely mental phenomenon, while the physical world still obeys Special Relativity. I talk a little more about this possibility in my concluding remarks in Chapter 5, specifically at 5.2.1.

problem in the theses we've looked it, where moments, times, objects, and events are (perhaps unintentionally) treated as synonymous, and discuss how to reformulate these theses in a neutral way. In 1.3.2, I then discuss the much broader issue with the ontological theses, which is that they are all formulated in terms of what exists. In understanding these existence claims, we can read them as tensed — in which case we cannot generate a dispute at all; nobody's denying, for instance, that only the present time exists *now*.[8] Alternatively, we can try to understand them as claims about existence *simpliciter*, but then it looks like we are committed to existence as a genuine property (which it is not). Or, we can try to understand them as being tenseless, but this is very difficult to do in a way that captures the meaning of the views, and in some cases generates nonsense. In each case, we cannot get the substantive metaphysical dispute we're after.

1.3.1 Terminology problems: moments, times, objects, or events?

First, all of the ontological theses tell us that something exists, but there are slight differences in the way they are spelled out: (POT) talks about which *moments* exist, (EOT) talks about which *times* exist, and (GBOT) talks about which *moments* and *events* exist (or not, as the case may be). In clarifying these theses, she also talks about which *objects* and *events* exist. These are meant to be parallel theses, not substantially different except with respect to whether the past, present, or future is being talked about, so I take it that either this is an oversight, or else we are supposed to treat moments, times, objects, and events as synonymous. One plausible reason for treating these obviously distinct concepts as synonymous is to avoid committing oneself to further ontology: for instance, moments and times might not exist independently if one is not a substantivalist about time — that is, if one does not believe that times can exist independently of their contents.[9] Also, one might

[8] As long as we take this in the neutral way I intended it; *not* to mean that there is a metaphysically-independent time t which corresponds to now, or that there is an objective property of presentness which now has. If you think that the objective property of presentness is really the thing at issue, see section 1.6.

[9] Much more is said about substantivalism and its opposing view, relationalism, in Chapter 3 of this dissertation. There I spend a good deal of time characterizing the views in a way that is less rough than what I've offered here.

not have events in one's ontological inventory either, and instead reduce them to objects (or objects instantiating properties, states of affairs, etc.).[10] It might make sense to further delineate the views at hand once one has decided whether substantivalism is true, what events are, etc. — for example, one might want to later distinguish a subview, substantivalist presentism, as opposed to relationalist presentism. But certainly these positions in temporal ontology are often held (and therefore can be held) without their holders being decided on other ontological issues.

What I will suggest for clarity's sake, therefore, is that we choose one word that we designate as ontologically neutral, and replace the varying terms in Miller's theses with it. I propose that we use *times*, on the following grounds: a relationalist can treat *times* as abstractions, but they will still exist for both the substantivalist and the non-substantivalist in *some* sense, even if they supervene on (or otherwise derive from) objects or states of affairs; whereas, if we go with some other term like 'events', we might leave the substantivalists without a way to characterize their own view, since they might hold that times necessarily exist and yet events do not necessarily exist. Further, using "objects" or "entities" would result in theses that are redundant for relationalists (i.e., "Only present objects exist" is redundant for someone who believes the present is *constituted solely by objects*).

So, revising the ontological theses with our new neutral terminology, we have:

6. POT* (Presentist Ontological Thesis): Only the present time exists.

7. EOT* (Eternalist Ontological Thesis): Past, present, and future times exist.

8. GBOT* (Growing Block Ontological Thesis): Past and present times exist, but future times do not exist.

[10] I am not taking a stance here on what the differences might be between events, objects, objects instantiating properties, and states of affairs. Nor am I defining them. I just think philosophers have tended to characterize these rather differently, and I don't want to tie the statements of positions in temporal ontology to a particular ontological inventory.

1.3.2 Problems with existence

But we have a big problem with these ontological theses, because we need to know what "exists" means (if indeed it means anything) if we are to set up the debate in this way. To be clear, I do not think we should set up the debate in this way, because I think to do so will end up either telling us nothing, or it will require that we accept that there is a genuine property of existence, and I think we should not accept that. But my stance here will require a little more elucidation, which I will do in the sections below. For now, I will start by taking the theses at face-value, and showing how to problematize them.

It has already been suggested that treating "exists" here as (present) tensed (as it appears in its surface linguistic form) is problematic. If (POT*) means "Only the present time exists now", where 'now' means 'at the present time', then that is trivially true, and similarly if (EOT*) means "Past, present, and future times exist now" that is trivially false. This won't do; it empties out the meaning of both positions.

So when the eternalist says, e.g., "Socrates exists", and the presentist denies this claim, it's hard to say exactly what is at metaphysical issue between them. Neither one of them would deny that Socrates did exist in the past, and both agree that he does not exist in the present. As previously mentioned, this has led some skeptics to think that when the presentist denies "Socrates exists", it's because the presentist is restricting the quantifier to the domain of only present things, while the eternalist includes past (and future) things in the domain of their quantifier. So, on this skeptical view, the two are talking past each other. The presentist denies "Socrates exists" because they take the existential quantifier to only range over present things, so "Socrates exists" means "Socrates exists now", which is obviously false on both views. But the eternalist accepts "Socrates exists", because they take the existential quantifier to range over past, present, and future things, so "Socrates exists" means "Socrates did exist, does exist, or will exist", which is obviously true on both views. But this interpretation would mean that the debate really just boils down to a linguistic dispute about how to use the word "exists" – the opposing parties would agree on all the

facts.

To put it another way, this would mean that (POT*) could be interpreted as "Only the present time exists now", and that (EOT*) could be interpreted as "Past times did exist, the present time exists now, and future times will exist." These are tensed readings; the second is just disjunctively tensed. But these are obviously bad renderings of the views. Neither of them means something as trivial as what we have here, and neither presentist nor eternalist disagrees with the *tensed* readings.

Any tensed reading of the ontological theses, then, not only fails to deliver the meaning of the positions, but also cannot generate a substantive dispute. So, two alternatives have been proposed: either we're supposed to take it that 'exists' means 'exists *simpliciter*' or that 'exists' is tenseless. I will address each in turn.

Problems with existence *simpliciter*

Miller herself clarifies that, for the theses in question, by "exists", she means "exists *simpliciter*". And she thinks that what is really at issue when we argue about, e.g., whether or not Socrates exists *simpliciter* is whether the sentence "Socrates exists" is true when the domain of quantification is unrestricted.[11] So the point of this addition is to try to generate a substantial ontological difference between these views: for her, it's a dispute over what is in the unrestricted domain. Miller's not alone in this thinking, either; Sider (2006), Crisp (2004), and others also think this is the best way to frame the problem.

This way of understanding "exists", however, does not help us make sense of the debate. To begin with, jumping to issues of semantic interpretation over a domain *before* the syntax is settled is putting the cart before the horse. That is, it's unclear that anyone should (or wants to) allow that existence is a genuine predicate, such that "Socrates exists" is a well-formed formula. If there is no such wff, then there's nothing to interpret over a domain. So we have to first agree on whether 'exists' is a genuine predicate at all.[12]

[11]This usage of existence *simpliciter*, to mean 'what exists when the domain of quantification is unrestricted', seems to trace to Lewis' 1986 *On the Plurality of Worlds*, p.3: "When we quantify over less than all there is, we leave out things that (unrestrictedly speaking) exist *simpliciter*."

[12]Where 'genuine predicate' should be understood as 'a predicate which expresses a genuine property', and

Many (if not most) philosophers today don't think existence is a genuine property. There are several reasons for this.

First, to treat existence as if it were a genuine property quickly leads down the road to (some form of) Meinongianism. For, if we think there are some objects that have the property of existing, we might have to admit that there are other objects which lack that property, and yet enjoy some other mode of reality. Meinongianism holds, roughly, that for every intentional act, there is an object. That is to say, if one thinks *about* something, then there must be something that one thinks about. If that something is non-existent, nevertheless it is still a something. For the Meinongian, an object's properties do not depend on whether or not the object exists. Russell and his followers reject Meinongianism because it leads to contradictions: if there is an object corresponding to every thing one thinks about, and if existence is a property, then one can imagine a golden mountain that also has the property of existence. Then it seems to follow that the golden mountain exists. But, of course, it doesn't exist. Meinong has an answer to this (that there is a difference between saying that something exists and saying that it has the property of existence) but not everyone accepts this answer.[13]

Other philosophers, following Aristotle, Hume, and Kant, reject existence as a genuine property because it doesn't seem to do any useful work: nothing substantial gets added to your description of an object when you add that it exists (assuming you've fully described the object). This might sound counterintuitive at first, since it certainly seems that whether or not an object exists is substantial information. But to grasp the idea, take any object

a 'genuine property' is a metaphysically substantive property. (I realize this is not much of a characterization of 'genuine property', but I am not sure what I want to say here beyond this. At any rate, there are notable plausible cases of predicates which do not express genuine properties, such as the disjunctive predicate 'being round or red', since it doesn't appear to be the case that that being-round-or-red is a property anything has.)

[13]In conversations with Gregory Landini and Landon D.C. Elkind, it was pointed out to me that the mere allowing of an existence predicate does not automatically buy one into Meinongianism. This is because the simple allowing of existence as a predicate doesn't imply that any old word will be a term that refers, or that any conceivable thing whatsoever will be an object that exists. So, one could technically allow an existence predicate and yet avoid Meinongianism by not having any non-existent objects in one's ontology. The existence predicate will simply have no work to do in such a case. Still, given the need to keep my discussion concise here, I think this is the quickest way to describe the common Russellian motivation for avoiding existence predicates.

whatsoever — a lemon in a bowl on your kitchen counter, for instance. If you fully describe the lemon, adding that it exists will not add any additional information. For, what could it possibly add? Perhaps one might think that it adds that the lemon is a concrete object in spacetime rather than an idea in your mind. Or maybe that the lemon has causal powers. But if you fully specify the lemon, these things will already be in your specification: you will have named the lemon's location in spacetime (being in a bowl in your kitchen), and you will have specified that the lemon is perceivable by others, etc. Existence isn't adding anything to the story of the lemon that can't be already specified by the things it often gets equivocated with: being concrete, having causal powers, being mind-independent, etc.

Or, to take a more complicated case: take the Easter Bunny. If you fully describe the Easter Bunny, including that it is a fictional character, you don't need to add that it exists; that would be confusing, since it would sound like you were saying that it was a non-fictional entity — until you disambiguated "exists" by specifying that it exists "as a fiction" (as opposed to "as a concrete object with a location in spacetime"). But once you do that necessary disambiguation, you're back to the full description you started with. For, you had already described the Easter Bunny as fictional. Fictional does not mean 'does not exist', even if it is casually used in this way; it means something along the lines of 'having its properties attributed to it by a story'. So the Easter Bunny has ears, and hops, and leaves chocolate eggs in the night, according to a story we tell. To say that the Easter Bunny exists, which we might say casually, is just to affirm that it's true that we tell a story about the Easter Bunny having such-and-such properties.[14] It's not to attribute to the Easter Bunny a property of existence. Similarly, to say that the Easter Bunny does not exist, which we might also say casually, is to emphasize the fact that the Easter Bunny's properties are attributed to it by a story.[15] It is not to attribute to the Easter Bunny the property of non-existence. Existence just has no work to play in a full description of the Easter Bunny, the lemon, or anything else, even if that's how we often loosely talk.

[14] And we often say, e.g., "The Easter Bunny exists *in the minds of children*..." as a means of clarification.

[15] And we often say, e.g., "The Easter Bunny doesn't exist *in real life*...", i.e., it doesn't have a spacetime location, which we infer from the fact that it has all its properties attributed to it by a story.

So there are at least two very solid reasons (the rejection of Meinongianism, and the lack of work for an 'existence' property) to outright reject the idea that existence is a genuine property. And if existence is not a genuine property, then 'exists' is not a genuine predicate. Thus, we have good reason to reject the grammar of the ontological theses we have used to characterize presentism, eternalism, and the others.

But that spells trouble for the idea that existence *simpliciter* is the kind of 'exists' we have in mind in our ontological theses. For, either 'Socrates exists *simpliciter*' means 'Something, namely Socrates, has the property of existence' or it means 'Something is such that it has the property of being Socrates'.[16] In the former case, if we don't accept that there is a genuine property of existence, then we should reject the grammar of 'Socrates exists', and then we should not be worried about issues of interpretation over a domain at all. Presumably, however, the people in this debate think they are just speaking casually, and mean something like the latter. Then their idea is that we have to decide what's in the unrestricted domain in order to decide whether the former is true.

But debating about what's in the unrestricted domain is nonsense. The only answer to "What's in the unrestricted domain?" is "Everything." Debating about whether it is true that 'Something is such that it has the property of being Socrates' is just to do ontology.[17] It's no help at all to say that presentists and eternalists are disagreeing on their ontology. We already know that. It doesn't help us formulate the dispute any further. The only other alternative, as I've suggested here, is to answer the question, "What's in the unrestricted domain?" with "Everything that *exists*", that is, to sneak existence-as-a-property back in. And if the point is really that the 'true' unrestricted domain is the eternalist one, since they aren't 'restricting' the domain to present objects, you're begging the question in favor of the eternalist, and leaving the presentist without a way to characterize their own view.[18]

[16] I mean this loosely here; not intended to imply that there is a genuine property 'being Socrates'. Perhaps there is such an essence of Socrates. Or it might be that 'being Socrates' is a conjunctive set of properties, i.e., a definite description. Substitute in whatever you like, for now.

[17] One might think here that this means the question should be addressed in terms of truthmaking. I will address this below, in section 1.4.

[18] This is not meant to just be uncharitable; as I mentioned, Lewis seems to be the originator of the term, and he says, in talking of what is in the unrestricted domain: "Likewise the world is inclusive in time. No

This proposal – that we should take 'exists' to mean 'exists *simpliciter*' – can't help us clarify anything. What exists is what's in the unrestricted domain. So, whether 'Socrates exists' is true when the domain of quantification is unrestricted doesn't tell us what's at metaphysical dispute between the presentist and the eternalist when they (claim to) argue about whether or not Socrates exists.

Problems with tenseless existence

There is another proposal for how to deal with the skeptic's triviality challenge, which is to understand 'exists' as tenseless.[19] The idea is that if an eternalist asserts "Socrates exists", and they don't mean the tensed "Socrates exists now" or "Socrates existed (in his lifetime)", then maybe they have a tenseless notion of existence in mind: by "Socrates exists", they are doing something akin to saying "2 is even".[20]

Of course, "2 is (tenselessly) even" and "Socrates exists (tenselessly)" might be very different animals. One way of understanding "2 is (tenselessly) even" is that it means "At all times, 2 is even". This is certainly true. But one might complain that this doesn't quite capture the meaning of "2 is even" — it's not that 2 is even at every time, but rather that "2 is even" is true regardless of time, or "outside" of temporal considerations. Fine; but Socrates is clearly not the kind of thing that exists outside of temporal considerations, so

long-gone ancient Romans, no long-gone pterodactyls, no long-gone primordial clouds of plasma are too far in the past, nor are the dead dark stars too far in the future to be part of this same world." (1986, p.1) Exactly as I've said, this seems to either beg the question in favor of the eternalist, or involves an implicit assumption that the ability to talk about something means that it must go in the unrestricted domain, that is, that it exists. Which leads us to Meinongianism, and surely we do not want to saddle everyone with such at the outset.

[19]For charity's sake, assume here that 'Socrates exists' is not attributing the property of existence to Socrates, but is just an informal way of saying, e.g., 'Something is such that it has the property of being Socrates', as discussed above.

[20]These sorts of "tenseless" predicates (e.g., as in "2 is even", or "Rabbits have ears", etc.) do have morphological tense; obviously 'is' and 'have' are in the simple present. But there is more to linguistic time than tense; there is also *aspect*, a grammatical feature which encodes information about the flow of time internal to the event in question. The ones I've mentioned here involve the "gnomic" aspect, which is sometimes utilized to express general truths or aphorisms which do not limit the flow of time to any particular conception. Gnomic aspect is expressed by using the simple present in English, but some other languages (e.g. Swahili) have discrete morphological markers to indicate the gnomic aspect. There are other aspects which are also expressed by using the simple present in English, such as the habitual aspect, as in 'John smokes'. I have increasingly thought that too much attention is paid to tense and not enough attention is paid to aspect within the philosophy of time.

this is presumably not the kind of tenselessness we have in mind. (And presumably, we also don't want to say that "Socrates exists (tenselessly)" means "At all times, Socrates exists", since that is obviously false.)

Perhaps what we mean by "Socrates exists (tenselessly)", then, is something like: (A) "There is some time t at which Socrates exists." Then we might ask whether that 'exists' in (A) is tensed or tenseless. It had better be tensed, on pain of regress — for if it's tenseless, then on our translation scheme, we should read it as (A*) "There is some time t at which there is some time t at which Socrates exists", and then we're off to the races. The lesson is that we cannot use tenseless language in the meta-language we are using to give the semantics for tenseless language.

But there are also difficulties with reading it as tensed. This is because tense functions to specify a time that an activity happens. If the 'exists' in (A) is supposed to be read as past-tensed, then it says (A**) "There is some t at which Socrates existed." Both sides can agree to this, because it's ambiguous: the eternalist can quantify over past times, of course, but the presentist can also agree that there is some time t at which (it's true) that Socrates existed, and that time is now: it is true *now* that Socrates existed. So it doesn't generate the dispute; the only real question will only be whether or not the presentist can give truthmakers for (A**). (This has motivated some to think that if tenselessness cannot give us a genuine debate, then perhaps truthmaking can; I turn to this in the next section (1.4).)

On the other hand, if the 'exists' in (A) is to be read as present-tensed, as it appears to be on the surface, then it says (A***) "There is some time t at which Socrates exists (now)." But that reads weirdly, precisely because the tense is trying to do the same work that "There is some time t" is meant to do: specify a time. The overall difficulty is to be located in the different ways in which the presentist and the eternalist want to specify (represent) a time. The presentist wants to take "now" as a primitive, picking out a particular time, the present; the eternalist wants to take "now" as an indexical, picking out things that are simultaneous with the utterance containing it. The mixture of the two approaches results in the weirdness

of things like (A***).

There is still work being done in trying to reconcile the two ways of speaking, but the debate has slowed because of the general recognition that this approach demonstrates a linguistic problem rather than getting at the substantial ontological one.[21]

The cost, however, of rejecting tenseless existence is that we are now out of options for understanding the ontological theses, at least in terms of existence. That is, if all we have is a tensed notion of existence, then (POT*) becomes "Only the present time exists presently", which is redundant and trivially true. (EOT*) either becomes "Past, present, and future times exist presently", which is trivially false, or else "The past existed, the present exists, and the future will exist", which is trivially true. And similarly for (GBOT*). But a tenseless notion of existence is very hard to understand, and generates nonsense in many cases, trivialities in others. And talk of existence *simpliciter* either commits us to treating existence as a genuine property, or says so little that it can't clarify anything.

1.4 Can truthmaking generate a substantial dispute?

So far we have not had much luck in characterizing the views at hand by talking about what exists. But there is an intuitive pull to the idea that presentists and eternalists disagree on what exists, or how many things exist. So, another common way to try to get at this disagreement is to frame the debate in terms of truthmakers.

Briefly, truthmaker theory is the view that *truths need truthmakers*, that is, something that makes them true. It is generally motivated by the strongly intuitive pull of the correspondence theory of truth, that is, the view that *truth is correspondence* (between our statements about the world (the truth-bearers) and the parts of the world that make them true (the truth-makers)). What the truthmaking relation is, what the truthbearers are, and *which* truths need truthmakers are all highly contentious areas of research. But only the latter need concern us here.

[21] See, for instance, Baron, Miller, and Tallant (2023), who argue that there is no reason to suppose that all philosophical positions must be equally linguistically representable.

Truthmaker Maximalism is a popular answer to that last concern. It tells us that *all* truths stand in need of truthmakers. The idea is that Maximalism best captures the motivation from correspondence theory: its proponents claim that it would be too *ad hoc* to claim that some truths are in need of truthmakers, while others aren't, since we are motivated by the view that what is true – *anything* that's true – depends on how the world is.

Now, Stoneham (2009) wants to move the temporal ontology debate onto truthmaker theory grounds because he is (like me) worried about the intelligibility of the notions of tenseless existence or existence *simpliciter*, and consequently (like me) doesn't think a substantial dispute can be generated via the usual ontological theses. So, he frames the debate in this way: presentists, he says, should embrace the following version of Truthmaker Maximalism (which eternalists should reject):

(TM1) If p is true, then there now exists some object x, such that *x exists* strictly implies p.[22]

Growing blockists, then, should embrace this version:

(TM3) If p is true, then there is or was some object x, such that the past or present existence of x strictly implies the truth of p.

And eternalists (and moving spotlight theorists, by extension) should embrace this one:

(TM4) If p is true, then either there is, was, or will be some object x, such that *x exists* strictly implies p.

[22]These formulations are Stoneham's, not mine. (This is why they are labeled "TM1", "TM3", and "TM4", skipping "TM2", which was not necessary for the discussion.) TM3 notably differs from TM1 and TM4 because it has the existence of an x strictly implying a proposition, instead of one proposition strictly implying another. But I take it we should really read it as parallel to the others, i.e., "such that *x exists* strictly implies p".

Now, Stoneham thinks, we have a substantial dispute between the views — one which does not turn on any notion of tenseless existence. And Deng (2017), discussing Stoneham, agrees that insisting all sides should embrace Truthmaker Maximalism, and framing the discussion in this way, is the right path forward in the attempt to figure out what the temporal ontology debate is all about.

For my part, I think there are good reasons to reject Truthmaker Maximalism, regardless of one's temporal ontology. But my view, like many others who are Truthmaker Non-maximalists, is motivated by concerns about the difficulty in finding appropriate truthmakers for certain classes of truths, particularly necessary truths and negative existential truths. In those cases, I think we will not be able to find truthmakers amongst the objects in the world, because I think those types of truths are not *about* objects in the world. However, even on my view, I think we will still need to find truthmakers for truths that *are* about (objects in) the world, *even if those truths are tensed*. Consequently, the project of trying to understand these views in terms of truthmakers need not be immediately rejected out of hand just on the grounds that one doesn't hold with Truthmaker Maximalism.[23]

But people often use presentism as a paradigm case of a view that may have difficulty locating appropriate truthmakers for certain kinds of claims. For instance, what, for a presentist, makes "Socrates was wise" true (if indeed it is true)? It seems that, unlike the eternalist, the presentist cannot appeal to Socrates, who doesn't presently exist. And so this is a fairly common challenge to presentism: it cannot give truthmakers for truths about the past.

It's common for presentists who attempt to meet this challenge to give an unsatisfying answer which goes something like: the world (as it presently is) could not be arranged in

[23]Perhaps the presentist could try to argue that past truths are not about objects in the world either, since the presentist doesn't hold that Socrates is (presently) an object in the world. Then they will need to specify what, e.g., 'Socrates existed' is actually about, and look for their truthmakers there. But I am doubtful that this is going to work, since the obvious candidates for what such sentences might be about, if they are not about the past, is that they are about the present, e.g., about our present memories or stories about the past. Then they are still about the world, and we still need to give truthmakers from the world for them. But they will run into relevancy problems like I describe below, in discussing the presentist attempt to say that truths about the past are made true by the entirety of the present.

this particular way unless the past was (the way it was). That is, *the entirety of the present* is the truthmaker for past truths. I call this answer unsatisfying because the entirety of the present is not what "Socrates was wise" is *about*. If our truths need truthmakers because we want truth to correspond to the world, surely we also want those truths to correspond to the *right parts* of the world.

However, I do not think this difficulty closes the door on presentism as handily as some may think. For, the eternalist has the same problem, though it is rarely noticed. Consider: what makes "Socrates was wise" true for the eternalist? The answer is supposed to be that Socrates *is* wise *at 440 BCE*, and since that state of affairs/that time exists for the eternalist, Socrates is able to be the truthmaker for the claim. But why should a truthmaker from the past make a present truth true? That is, it's true *now* that Socrates was wise; so why am I allowed to look at other times for a truthmaker? And if I *am* so allowed, then what's to stop the presentist doing the same thing? Why can't the presentist say that Socrates having been wise in the past makes "Socrates was wise" true today? Is it because truthmakers have to exist? Well, do they have to exist *now*? If so, then eternalists can't use Socrates either, since he is located in the past. If not, and truthmakers just have to exist at some point in time, then presentists *can* use Socrates, even though he doesn't presently exist.

What makes it true that "Socrates was wise" is that Socrates once *made* it true that "Socrates is wise". Truths about how the world is should be made true by the way the world is. But truths about how the world was should be made true by how the world *was*. We don't need to appeal to presently existing relics of the past, such as corpses and the like — those are just how we *know* how the world was. That's an epistemic concern, separate from the metaphysical concern of how things actually are (and were). And, crucially, presentists are not saying that the past never happened; only that it's not still *happening*.

So our result is that either (1) both presentists and eternalists can help themselves to past truthmakers for past truths, or (2) neither of them are licensed to use past truthmakers. The only other way out, as far as I can tell, is if by 'exist' (i.e., in "truthmakers have to exist") one is aiming at "tenselessly exist", which, as I've already discussed in the previous

section, is very problematic, and is also what Stoneham is trying to avoid. But notice that this untangling of the supposed problem of truthmakers for presentists results in the undercutting of Stoneham's attempt to frame the debate in terms of truthmakers. For, adherents of *any* temporal ontology can embrace (TM4), and *no one* should embrace (TM1). But then we don't have anything left to set up a dispute, since everyone will be in agreement.

For her part, Deng almost gets to where I am – she acknowledges the central thrust of what I've said here – but ultimately rejects it because it doesn't generate a substantial dispute between eternalists and presentists. She wants to re-introduce the problematic notion of tenselessness, contra Stoneham, to generate a real dispute via truthmaking. But I think a better path is just to reject the idea that the debate should be framed in terms of truthmaking at all.

1.5 Can we salvage the ontological theses? A lesson about ontology

So far we have failed to generate a substantive dispute about temporal ontology. Attempts to make *direct* claims about what exists are beset by deep problems, including both the likely-illegitimate use of existence as a property, and troubles making sense of tenselessness. Attempts to make *indirect* claims about what exists (by appealing to truthmaker theory) end up inheriting the problem of tenselessness or simply cannot generate a dispute.

I think there is a lesson here to be learned about ontology in general. Ontology is usually thought of as the study of "what there is", but it is also the study of what *what there is* is like — that is, the study of the *features* of what exists. If the grammar of existence is unwieldy or illegitimate, then perhaps it is better for us to focus our theorizing on *characterizing* what exists, rather than trying to make declarations about existence. Thus, in our attempts to characterize temporal ontology, we could simply throw up our hands, stomp our feet, and insist that temporal ontology is about *what exists when*. But from here on out, given the problems we've encountered, I recommend that we take a different route. Let us see if we can

generate a substantial ontological dispute about temporal ontology by utilizing theses that tell us what times are *like*– what features and properties they have. It may happily turn out that all our intuitions about *what exists when* are simply parasitic on our intuitions about how time works to begin with.

1.6 The revised Static vs. Dynamic theses, or, how to generate a dispute with passage

Fortunately, we already have two other theses at our ready disposal that attempt to tell us what time is like — namely, what Miller calls the Dynamical Thesis and the Static Thesis. (These are not *called* the ontological theses, but they are ontological theses nonetheless.) As a reminder, here are those two theses again, as Miller has them (and which I aim to problematize in a moment):

DT (Dynamical Thesis): The present moves: which moment is the present moment changes.

ST (Static Thesis): The present does not move: which moment is the present moment does not change.

I am not sure what it means to say that the present "moves" – for the present is not the sort of entity that can change spatial location. But the proposition following the colon in each thesis appears to be meant as a clarification. So, removing the puzzling reference to the present moving, and swapping out 'moment' for the neutral word 'time' (for the same reasons we did this in earlier sections), we arrive at:

DT*: Which time is the present time changes.

ST*: Which time is the present time does not change.

Change is itself a temporal notion, so it is difficult to cash out these theses in the terms presented here. That is, there is not much clarification in cashing out (DT*) and (ST*) as follows:

DT**: The time that has the property of being present is different over time.

ST**: The time that has the property of being present is not different over time.

These are not useful because it is hard to understand what it means for a time to be "different over time". Moreover, the parallel structure of these two theses is misleading, since what is meant by "the time that has the property of being present" is different in each one. For, Miller clarifies that the reason the present does not change for the static theorist is because there is no such (metaphysically weighty) feature of the world as "the present". "The present" is, for the static theorist, merely an indexical, picking out the time of utterance. By contrast, the dynamic theorist accepts an objective property of presentness. So, our theses *actually* say:

DT***: Which time has the objective property of being present is different over time.

ST***: Which time contains this utterance is not different over time.

But this, of course, is not an instance of p vs. $\sim p$. In fact, no one disagrees with (ST***), which is not good, since not everyone is a static theorist.

(DT***) offers a bit more promise, since the static theorist disagrees with it on the grounds that there is no objective property of presentness. But the existence (or lack thereof) of the property of presentness is not what's actually doing the work here. It's the "different over time" part that's doing the work — a part which we still have not satisfactorily parsed.

To see this, consider what happens if we focus more closely on a disagreement about the property of presentness:

OPP: There is an objective property of presentness.

NOPP: There is no objective property of presentness.

This is clearly a substantive dispute, but is it the dispute we're after? Is a disagreement about the existence of an objective property of presentness really the heart of the difference between (e.g.) presentists and eternalists?

Well, what is an objective property of presentness? It is a metaphysically special feature of one time and one time only – the present – which is special *because* it belongs to one time and one time only. This time would have this feature even if there were no minds to make claims involving indexicals, because it is an objective property.

But that still doesn't tell us anything about the feature. What is added or taken away when we describe something as *objectively present* or not? At first pass, it's hard to see how the answer isn't just supposed to be *existence*, for the presentist. And then we've just snuck problematic existence talk back into our view, under the guise of (OPP).

But what about for the growing blockist or moving spotlighter? They apparently endorse an objective property of presentness, and yet they do not deny the existence of the past. So presentness, for them, cannot just be existence. It must be something else. What makes the time which has the objective property of presentness different from other times in the block?

I submit that the difference is *passage*. Unlike the rest of the block, the time that has the objective property of presentness is dynamic, that is, subject to temporal passage, whatever that is supposed to be. And there is also passage inherent to presentness for the presentist, for whom there are not other times in the block (as there's no block!).[24] So, assuming we do not want to go chasing our tails about existence again, it seems that **temporal passage** at last offers us a way to understand what is at dispute in temporal ontology.

Indeed, passage is what is being gestured at in the phrase "different over time" from (DT***), which I earlier claimed was doing all the work, rather than "presentness" itself. But if it's just passage doing the work, then we can dispense with the reference to present-

[24]See, for instance, Baron (2017), an A-theorist who links passage to presentness in several places.

ness, and try to reformulate our theses appropriately:

New Dynamic Thesis (NDT): Temporal passage is a feature of the physical world.

New Static Thesis (NST): Temporal passage is not a feature of the physical world.

Now we have found a substantive ontological dispute about time, which I aimed to show did exist. I acknowledge that there might be other substantive issues, too, but until someone finds a way to neutrally articulate them, I think we are largely stuck talking past each other. Passage, though, is something we might actually be able to make some headway with, since we're at least able to articulate a meaningful difference here.

I assume that most people would cite presentists, growing blockists, and moving spotlighters as embracing (NDT), and eternalists as embracing (NST). Are these apparently four rival camps really just two rival camps: dynamic theorists and static theorists? The answer will turn on what *temporal passage* is, and what its implications are. So, in the next chapter, I set out to try to understand temporal passage, both by examining what others have said about it, and by offering my own characterization.

Chapter 2

MAKING SENSE OF THE NOTION OF TIME'S PASSAGE

> "There is passage, but it is nothing extra. It is the mere happening of things, their strung-along-ness in the manifold." (D. C. Williams, 1951)
>
> "There is time because there are happenings, and apart from happenings there is nothing." (Alfred North Whitehead, 1920, p.66)

2.1 Introduction

If temporal passage is the crux of any substantive debate about temporal ontology, then we need to know what exactly it is supposed to be. There have been very few explicit attempts to give an account of the concept of passage, even by its defenders; it is often simply taken as a primitive. And for disbelievers in passage, its treatment as mysterious primitive about which nothing can be said is surely just more reason to disbelieve. After all, skepticism about things we're asked to add to our ontology without even so much as a characterization of them seems generally philosophically healthy. Moreover, one ought to be slower to say that something is unanalyzable than to say that one's powers of analysis have run out, and so taking some concept or predicate as a primitive requires some defense (at least outside of formal systems).[1]

[1]Here and throughout, when I say 'primitive' I mean (something like) 'conceptual primitive', that is, a concept or predicate which cannot be further analyzed. But one might distinguish conceptual primitives from semantic primitives, as in the work of the linguist Anna Wierzbicka, which, though closely related, builds in the idea of universality of linguistic representation (that is, semantic primitives are supposed to be words that show up in every language and pick out the same things).

Moreover, because people are often somewhat loose in talking of primitives, it's worth repeating that only concepts or predicates can be (conceptual) primitives. That is, we do not analyze, e.g., redness itself, *qua* entity in the world, but rather the concept of redness. The tendency towards sloppiness here might be a result of a related intuition that things which are primitive, especially things like temporal passage, are also in some way ontologically fundamental. But this is a different claim altogether, and fundamentality of an entity is neither necessary nor sufficient for the primitiveness of its corresponding concept. (See Perovic (2016).)

Yet plausibly there *are* primitives in a world where we don't expect turtles all the way down, so to speak, and perhaps the concept of temporal passage is amongst them. Still, even if temporal passage does turn out to be a primitive, this does not give us license to say nothing about it at all; there is still the important work of characterizing it in a useful way. Within set theory, for instance, the concept of a set is a primitive; yet obviously we are able to informally characterize what a set is — a set is a collection of elements. And for many philosophers, modal notions like possibility may be taken as primitive; but we know that to talk about a possible world is to talk about a way that the world could have been. In both of these examples, we run into unavoidable circularity (set/collection, possible/could have been), which is what excludes characterizations like these from being proper definitions or analyses. But as Lewis (1983, p.20) tells us: "Not every account is an *analysis*!" Characterizations-as-accounts (should) tell us what work a notion is playing in our theory, and point to the relationships a particular notion bears to other notions within that theory.

So, even if it turns out that the concept of temporal passage is in fact a primitive, by characterizing it as robustly as we are able, we can see more clearly whether passage is something we want to adopt or reject in our ontology by looking at the functional role it is meant to play there and then trying to determine whether it lives up to the job, rather than simply relying on a general taste or distaste for mystery.[2]

Accordingly, the aim in this chapter is to find out what useful accounts of passage there might be. I begin (in 2.2) by taking an inventory of some of the existing accounts of passage in the literature. I have divided up these existing accounts into types: hyperplane-type accounts, accumulation-type accounts, actualization-type accounts, and succession-type accounts. I will summarize and review each type, providing examples of people who have held each type, and offer some critique. Then, having mapped the general layout of the existing conceptual territory, I will turn (in section 2.3) to asking what it is that these accounts are after. That is, why should we believe in passage at all? What is it that temporal passage is supposed to buy us? I suggest that what drives our belief in passage is also what unifies the varied

[2]And, of course, we might also want to ask ourselves whether the job is even necessary.

accounts of passage we will discuss in this chapter: an underlying inference from change to passage. This will require an investigation of what we mean by "change". I will examine the account of change that most, if not all, modern literature on time invokes, whether explicitly or implicitly: the "at-at" account of change, a modified version of Russell's "at-at" account of motion. I will criticize this account, showing that it fails as an account of temporal passage *qua* change because it contains a number of dubious presuppositions, including that substantivalism is true and that there are discrete objects and discrete times. Finally, in section 2.4, I will offer my own account of temporal passage, again *qua* change, but with a different intrinsic unit of change: process.

2.2 Existing accounts of temporal passage

Perhaps what has been most commonly offered about passage in the literature is the view according to which passage is change in which entities have A-theoretic properties (being present, being past, being future). So (to take just a few examples) we have Skow (2011), who tells us that passage is the fact that which moment is the present keeps changing, that is, passage is change in which time has presentness; the venerable Prior (1968), who tells us that passage is the "becoming ever more past" of events; and Markosian (2004), who describes passage as "the process by which times become less and less future, and then present, and then more and more past". Opponents of passage often describe passage in this way as well, both because it is a very common way of "explaining" passage by proponents of such, and because it contains the core of what such opponents generally want to decry: the idea of a (privileged, objective) property of presentness.

Authors who describe passage thusly generally give us little more than that in terms of a characterization, and are instead focused on defending (or attacking) various temporal ontologies or on questions of existence ontology: given a property of presentness, what can be said about what exists? Is presentism true? What is the ontological status of an object in the past? What can we do about truthmakers for the past and the future? Etc. But

they do not tell us what exactly these temporal properties are supposed to be, or give us a litmus test for determining which events or objects or times have a given temporal property, and (I think most importantly) they do not explain how the process of changing temporal properties takes place. For this reason, I do not call this sort of description an *account* of passage; even while any account of passage might have some circularity involved in the way I discussed in the previous section, these views about passage are *too* circular, too anemic to tell us anything much about what role passage is supposed to be playing in the world. We need more, in a good characterization of passage, than just "some things are present, whatever that is supposed to mean, and then they are not".

This point is perhaps best made by way of contrast — that is, by looking at accounts of passage which *do* deserve the label of "account": few and far between as they may be, they are illustrative of different ways one might reasonably go about fleshing out an account of temporal passage. To this end, I have collected the best examples of extant accounts of temporal passage and sorted them according to the following typology:

1. **Hyperplane-type passage**: Passage as (substantivalist) times, themselves changing with respect to a hypertime of some sort

2. **Accumulation-type passage**: Passage as the accumulation of entities (such as events)

3. **Actualization-type passage**: Passage as the actualization (or deactualization) of possibilia, where times are conceived of as possible worlds

4. **Succession-type passage**: Passage as the asymmetric succession of sets of simultaneous events

In what follows, I will describe and critically examine each of these types of characterization of passage.

2.2.1 Hyperplane-type passage

On this version of passage, temporal passage consists of times (which are not abstractions, but substantial, metaphysically independent entities) themselves changing against the backdrop of a "hypertime" or hyperplane of some sort. That is, passage consists of time itself (or, more accurately, times themselves) changing, and because change is a temporal notion (for change is the having of different properties at different *times*), there must be some sort of hypertime, itself unchanging, against which we measure that change.

Richard Taylor (1974) has offered the most fully-developed account involving this kind of passage, which he calls "pure becoming".[3] According to Taylor, pure becoming is presupposed by all other changes, because in order for an object to change, it must pass through a certain amount of time. This pure becoming is *just* "passing through a certain amount of time" or simply "getting older", and does not itself presuppose any other changes:

> 'By *pure becoming*, however, we have in mind becoming older simply in the sense of acquiring a greater age, whether that increase of age is attended by any other changes or not. In this sense a thing can become older without undergoing any other change whatever, for it can simply increase in age from one day to the next. This, then, seems to be a kind of becoming or passing through time that can be asserted of anything whatever that exists in time, for it is a consequence simply of its being in time. (Taylor 1974, p.84) [4]

Moreover, pure becoming also applies to times themselves – for, Taylor says, a day is a time, and a day gets older: it grows closer to its end. And while he acknowledges the overall strangeness of his view – particularly this hyperplane aspect, for what would such an entity be? – he points out that we do, in fact, regularly talk about intervals (like days or hours)

[3] I do not call this kind of account "Pure Becoming-type passage", despite Taylor being the only really notable proponent of it, because there are simply too many locutions in the literature which are very similar and yet express very different ideas of passage, e.g., the "absolute becoming" of Broad, or simply "becoming" by a great many others.

[4] I might have reasonably called this view "Aging-type passage".

changing and passing through time, and we understand each other perfectly well when we do so.

Taylor's view of temporal passage is as though time were a moving walkway: the walkway itself moves, while things on the walkway also move. Similarly, times themselves change, while the objects (or events) at those times change as well. Nothing will get anywhere unless the walkway moves; but the walkway can move without anything on it. And the walkway itself is known to be moving because of the hypertime (Taylor calls it "metaphysical time"): the unmoving backdrop (perhaps an empty airport, to continue the metaphor?) upon which it is observed.

I think Taylor's view is admirable for its willingness to engage with our naïve conceptions of time. He takes the ordinary metaphors we use in talking about time and runs with them, and this is intentional, not mere sloppiness; his motivation in so doing is to wholeheartedly embrace the datum that we ultimately must start with in any investigation of time, which is our phenomenology as of temporal passage. After all, he says, no one – not even the most staunch static theorist — really believes that their death is not *approaching*. We engage with the world in every way as if time were passing; indeed, it is unclear what it would mean to try to do otherwise. And Taylor says (and I think he is correct) that we would be sloppy scholars if we were too quick to dismiss this basic feature of our phenomenal life simply because it seems very puzzling.

I am less bullish about Taylor's appeals to ordinary language as another important starting datum. For Taylor, anyone who wants to argue temporal passage away is engaged in trying to deny that some of our most basic shared concepts about the world track anything at all. To succeed at such a task, he thinks that a person would need to provide some way of reformulating sentences like "The day is coming to an end" in a way which still has the same truth conditions and yet eliminates the idea of passage contained in it, *without* simultaneously eliminating the idea of time altogether. And this reformulation, he argues, is impossible, for reasons I won't fully replicate here, but which echo McTaggart (1908) strongly in the portion of McTaggart's argument which makes a case against the B-theory (static theory) on

the grounds that B-theoretic relational properties (e.g., before, simultaneous with, after) are insufficient to express genuine change.

But quite a lot has already been said about this kind of linguistic strategy in the last century of wrestling with McTaggart. B-theorists often respond that the charge that B-theoretic relations are insufficient to comprise "genuine" change is simply begging the question, since on their version of change, there is nothing more to express outside of objects at times standing in B-theoretic relations to objects at other times.

For my purposes, I will only add here that ordinary language makes expressing some ideas very difficult (have you ever tried to explain to someone who's never had alcohol what it is like to be drunk?) and makes expressing many other apparently meaningless things very easy ("'Twas brillig, and the slithy toves did gyre and gimble in the wabe..."). Whether ordinary natural language can express something (or not) does not necessarily give us evidence as to whether the thing in question is a real feature of the world.[5]

Moreoever, Taylor's view suffers from at least two other serious problems:

First, he openly admits that because pure becoming is independent of any other changes, it is unobservable, and therefore our knowledge of it is purely a priori. This seems in conflict with the first motivation that I mentioned earlier: to embrace the phenomenological data. Do we know of time's passage because of our experiences of it, or not? If respecting the phenomenology of passage is a serious motivation for (and therefore meant to be a virtue of) one's view, then it would be poor form not to manage to keep that aspect in one's overall story somehow. So it seems that Taylor must say that while we do not directly observe the passage of time, we nevertheless do so indirectly. Consequently, we would need a story about how this indirect observation is supposed to work.

One might try to rescue Taylor here by saying something like: "I directly observe changes

[5]I think this goes for formal languages, too. There is a certain type of philosopher who sometimes points to the difficulty of capturing tense in formal logic as evidence that tense does not reflect anything about the actual world. For my part, I am perfectly happy to allow logic to operate tenselessly, both because I do not think the last word has been said with respect to formalizing tense, and because more generally, I do not expect formalizations to be able to represent everything. Languages are models and all models are imprecise. More on this later.

in an object, and I know that change is just a matter of an object having different properties at different times, and therefore there are times." But we wouldn't define change in this way if we didn't *already* have a concept of time; so this doesn't seem a viable way to explain how we get from direct observation of change to a priori knowledge of the reality of the passage of time.

We might try another line, according to which we simply identify change, any change, with the passage of time. That is, we might say, "When I say 'Things change', I *mean* 'Time passes', and vice versa. So, then, whenever I observe some particular change, I know that things change, and so I know that time passes." But in order to get from "I know that time passes because I know that things change" to "I know that time passes *independently of any change whatsoever*" (which is Taylor's pure becoming), we would have to make a distinction between things changing and time passing. And so we've pulled the rug out from under our own attempt at vindicating his view.

Relatedly, even if Taylor is somehow able to account for how it is that we indirectly observe time's passage, it's unclear how he would then account for his notion of "metaphysical time" / hypertime. I assume Taylor would have it that we know of hypertime *a priori* because it *must* exist for times to be born and age and die in, but now we are very far afield from our ordinary experiences and even our ordinary way of talking about time. (While I acknowledge that we do talk about days "coming to an end" and so on, I don't think we generally talk about days themselves moving through a space of unmoving time, or the like.[6])

Secondly, Taylor's view is quite clearly substantivalist: times can exist without change (e.g., in the objects occupying them), and are themselves entities which can undergo property changes. (Presumably, the hypertime can also exist without times to occupy it.) This means his view inherits all the standard objections to classical substantivalism. For example, what is the occupying relation that holds between objects (or events) and the times they are "at"? For that matter, what are these entities called times, and what are they like, independent of

[6]And at any rate, talk of "days coming to an end" seems to me to be a way of talking about clocks and calendars and so on, and not at all a way of talking about times as metaphysically independent entities.

their contents?[7]

For Taylor's view to work, we need a hypertime because we need a backdrop upon which to recognize that these substantival times change (age); but what is that hypertime, and if it is unchanging, is it only temporal in the sense that it is what we recognize change against? Moreover, if hypertime is not required by any physical theory and is at any rate unobservable, is the only reason to believe in hypertime that it is required to make sense of Taylor's substantivalist times? If so, it seems that it would be more parsimonious to reject Taylor's pure becoming altogether in favor of a view in which times are not substantivalist and therefore do not require any such hypertime. But Taylor's pure becoming requires substantivalist times, and so this type of account of passage would have to be abandoned altogether if one abandons substantivalism.[8]

2.2.2 Accumulation-type passage

Next, let us look at the second kind of account of passage, that is, accumulation-type passage. Various versions of Growing Block Theory are perhaps the most salient here, as the Growing Block universe's "growing" is often cashed out as the "accumulation" of "temporal slices" at the end of the "block". This is, to take an influential example, the view of C.D. Broad, at least after his 1923 *Scientific Thought*:[9]

> Nothing has happened to the present by becoming past except that fresh slices of existence have been added to the total history of the world. The past is thus as real as the present. On the other hand, the essence of a present event is, not that

[7]A much more detailed discussion of substantivalism is to be found in Chapter 3, in which I demonstrate a number of good reasons not to be a substantivalist.

[8]As I said in the previous footnote, I will discuss this in substantivalism more in Chapter 3. But I will say that there are many substantivalist views about time – specifically, spacetime – which are live today, many of which are found in the structural realist camp. According to such views, the *structure* of spacetime is ontologically fundamental and substantive, and times (spacetime points or intervals) are constituted by – that is, dependent for their being on – aggregates of relations. These relations are ontologically prior to the relata, and in some versions, the relata don't exist in any substantive way at all — but in all versions, spacetime relations are real in a metaphysically heavy way. I will say no more about these views here, because at any rate, such views are inherently static-theorist in nature (at least as I understand them) and so can't help as an account of (dynamic) temporal passage, as this view is meant to be.

[9]Broad had defended an eternalist view in his 1921 *Time*.

> it precedes future events, but that there is quite literally *nothing* to which it has the relation of precedence. The sum total of existence is always increasing, and it is this which gives the time-series a sense [i.e. direction] as well as an order. A moment t is later than a moment $t*$ if the sum total of existence at t includes the sum total of existence $t*$ together with something more. (p.66–7; Broad's italics)

What does it mean for a fresh slice of existence to be added to the world? Not for something non-existent to gain the property of existing – Broad is clearly against treating existence as a property - but rather it is for a (previously non-existent) event to become, that is, to come into existence (which he also calls "Becoming" or (in later works) "absolute becoming"). The difference between an entity that exists and an entity that doesn't exist is not that one has the property of existence and the other doesn't, but that the entity that exists instantiates properties at all: Broad's Becoming is for an entity to begin to instantiate properties.

For Broad, once something exists it always exists: it is part of the "sum total of existence", the entirety of facts about the world, and when some event recedes into the past it only gains new (B-theoretic) relations to present events which it could not have had before (i.e., x's coming before y). But a present event's becoming past and a new event's Becoming (in the sense of coming into existence) are importantly asymmetrical: it is the fact that new events come into existence that allows events to become past and gain new relations, for the coming of a new event into existence provides new relata to which past events can now stand in relations. In this way, Broad's Becoming is ontologically prior to all other kinds of change, whether change of events from present to past, or simple qualitative change in entities.

With respect to the latter kind of change, Broad agrees with Taylor's view that changes *of* time are not the same as changes *in* time, though he provides a different line of reasoning as to why. He says that to take a static, at-at view of change in properties, according to which change is just an object at one time being qualitatively different from the same object at another time, is to give a circular analysis: for such an analysis depends on *there being*

other times, that is, depends on there being a t_2 to follow a t_1 — and so depends on times themselves changing. So he thinks that one needs times themselves to change in order to have change in an object.[10] But Broad ultimately disagrees with Taylor's overall theory of passage because he thinks that invoking a hypertime leads to a vicious regress: in order for hypertime to be temporal in nature at all, it would have to change, and then one would need yet another hypertime to account for it, and so on down.

Another notable proponent of accumulation-type passage is Michael Tooley, whose 1997 *Time, Tense, and Causation* was a landmark work in contemporary Growing Block thought. According to Tooley, the natural way to explain the difference between static and dynamic conceptions of the world is in terms of competing concepts of change. There is the concept of change associated with the static view, according to which for an object to change is simply for it to have different properties at different times. The alternative associated with tensed approaches, according to Tooley, is that an object changes *iff* there is change over time in the totality of the monadic states of affairs involving the object. Further, the world as a whole changes (according to Tooley's dynamic conception) if the totality of temporal facts (states of affairs) is different at different times (though one can drop the monadic restriction when considering change at the level of totality facts, as at such a level one does not need to worry about accidentally including so-called 'Cambridge change', where an object changes only because another object to which it stands in a relation has itself changed). Totality facts (in this sense) are able to change because they are fundamentally temporally relative, that is, there are totality facts *as of* one time and totality facts *as of* another — so that the basic notion is not that of states of affairs being actual *simpliciter*, but that of states of affairs existing (being actual) *as of* a particular time.[11]

[10] And this, I think, commits him to at-at change still, just in a broader way: he wants change to consist of there being one time, which is a total state of affairs, coming into existence and thus gaining the property of being the "edge" of the block, and then losing that property when another total state of affairs (another time) comes into existence. So it is at-at change, but in times rather than individual objects. More on at-at change later, in 2.3.1.

[11] So, again with Tooley, we see a commitment to at-at change at a broader level: the growing blockist has a view according to which change is just there being one totality fact at one time and a different totality fact at another time.

> To sum up, then, the difference between a static conception of the world and a dynamic one comes to this. According to a static conception, what states of affairs there are does not depend on what time it is. Change, consequently, cannot be a matter of of change, over time, in what states of affairs exist. It must be a matter simply of the possession, by an object, or by the world as a whole, of different intrinsic properties at different times. According to a dynamic conception of the world, by contrast, what states of affairs exist does depend upon what time it is. As a consequence, the totality of monadic states of affairs which exist as of one time, and which involve a given object, may differ from the totality that exists as of some other time, and it is precisely such a difference that constitutes change in an object, rather than merely the possession by an object of different properties at different times. (1997, p. 16)

So for Tooley, as for Broad, change in totality facts is ontologically required for change in an object. Change in an object is therefore parasitic on change in the entire world, that is, on change in times.

Where Tooley's otherwise very detailed analysis of philosophical issues concerning time comes up scant is largely in the fact that he does not directly try to explain the accumulation aspect of his accumulation-type account of passage. Tooley defends a dynamic, Growing Blockist conception of time, since he is committed to a dynamic view for the reasons above, but he rejects the dynamic-theory alternative, Presentism, for not being able to account for truthmakers for true sentences about the past. But how it is exactly that temporal slices are supposed to be added onto the block he does not say. Where this becomes an issue, he simply invokes Broad's account, holding that the notion of events coming into existence can surely be made sense of (or at least as much sense as competing accounts of passage) and that the view has enough other strengths to make it preferable to its competition.

It is this last that is perhaps the most difficult aspect of the accumulation view of passage: neither Broad nor Tooley, incredibly systematic thinkers though they may be, offers any real

explanation for what it means for events to come into existence or for temporal slices to accumulate. This is not to complain that passage is a primitive for them (for accounts do not have to be analyses!) but that their accounts are somewhat unclear. In some places they both seem to say that temporal passage consists of events - which are typically thought of as having some non-instantaneous duration - coming into existence; but at other places, passage is the accumulation of temporal slices ("fresh slices of existence"), which are typically thought of as instantaneous. Which of the two is meant to be ontologically prior, events or time slices? That is, is the passage of time discrete or continuous, on this kind of account?

Moreover, at other places, they both say that passage is constituted in change in totality facts (that is, facts about the "sum total of existence" or the "totality of states of affairs") and unequivocally state that change in such totality facts is ontologically prior to other sorts of change, including changes in events or objects. But the authors do not tell us anything to help us understand whether a given totality fact *comprises* a time (a time-slice?) or *occupies* a time. That is, they do not clarify if they have a substantivalist view or a relationist one. Is the present a location in the block – its "growing edge" – which, at every moment, a new totality fact begins to occupy, or is it rather that the edge of the block *is* a totality fact and the fact of its being the edge constitutes its being the present?

And proponents of this view seem to remain silent on how it is that this accumulation or coming into existence works. It seems unlikely that they think that God waves a wand at the end of the block and create new entities at every moment. Perhaps they think that the laws of physics somehow *produce* new events out of the previous ones, but this would seem ad hoc, since the laws of physics don't tell us anything about totality facts. And it can't be that change in (lower-level) entities is the cause of the coming into existence of new totality facts, since change in entities is explicitly dependent on totality-fact change in their view.

2.2.3 Actualization-type passage

One way to try to answer some of the questions left open by the accumulation view of passage is to take an actualization-type view instead, according to which temporal passage

is the successive actualization (or deactualization) of possibilia, where times are conceived of as possible worlds in some sense.

A notable proponent of this view is Storrs McCall (1974), who defended a unique growing block-esque view according to which the past and the present are actual, but future times are possible worlds which can be represented as branches on a tree. Time's objective flow then consists of (or, he suggests at one point, *is generated by*) these possible future branches falling away as one of the future branches becomes actual (present). To put it another way, all there is to passage (according to McCall) is the fact that which future possibilities exist is different *at each moment*, and because the state of the "universe-tree" is time-dependent in this ontologically substantial way, it is therefore genuinely dynamic — even though on his model, the state of the universe is still frame-variant, and so time does not have an objective *global* flow.

One might think that if the state of the universe is frame-variant, it's hard to see how there could be a privileged (non-arbitrary) present anywhere (even locally), or any future branches which are not already actualized, since what is future in one frame will be present or past in another. But McCall argues that frame-variance is *required* for an objective time flow, since in order for events to be organized temporally, they must be able to be placed in simultaneity classes, which requires selecting a frame of reference; and from a frame-time of 1976, what you would call the present is *not* an arbitrary choice but a forced one — the present of 1976 is 1976, and the future possibilities which might actualize or fall away are *not* already actualized or fallen *from that frame-time*. (Note that McCall is careful to distinguish between observer-variance and frame-variance; he does not mean to say that for an observer in 1976, the present is present and the future is undetermined, but rather that, objectively speaking, the four-dimensional manifold which comprises the universe in 1976 has an open (branching) future.)

Another version of actualization-type passage, though more presentist in flavor, comes from Bigelow (1991). Bigelow rejects McCall's assertion that for things to be present they must be put in a simultaneity class, arguing that in a world with just one object, that

object would be present in that frame-time, without the need for further entities to exist simultaneously with. Therefore, he says, it is possible for something to have an intrinsic property of presentness relative to a frame, without that idea collapsing into mere indexicality (since the property is intrinsic precisely to the *pair* of the object and its frame).

Having potentially rescued the privileged present, and since presentism is often taken to be the folk view or common-sense view of time, Bigelow then turns to what he claims is our ordinary way of thinking about passage, according to which passage is the fact that *What is present was future and will be past.*[12] But rather than give the typical indexical analysis of this sentence, he offers a modal analysis, re-evaluating that sentence as *What is actually present could have been future and could have been past.* He then attempts to develop a modal view of passage, according to which times are to be understood as possible worlds which have a special kind of temporal accessibility relation; times-as-worlds are temporally accessible from each other when they differ only in their temporal relations to each other.[13]

> All that actually exists is the present. Things have the property of being past, not by existing in the actual world and having the property of pastness, but by existing in some other possible world which is "in the actual world's past". Something which is past in w is something which *did* exist in w: but this means, not that it does exist in w with a special property, but that it does exist in some other world which is related in a distinctive way to w, a world in w's past....There are no dodos. There were dodos, because if some past time had been present then it would have been the case that dodos exist. Yet in the actual world it is not the case that dodos exist. (p.16-17)

[12] As I mentioned at the beginning of section 2.2, there is a great deal of literature which describes passage in exactly this way, where passage is just change in what times have A-theoretic properties. To give a few more recent examples of a very commonly expressed thought, we read in Loss (2022) that passage is the fact that "some time t is such that it was the case that t is present and yet t is not present anymore"; in Riggs (2018) that time passes with the result that the past is different from the future; and in Norton (2010): "Time passes. Nothing fancy is meant by that. It is just the mundane fact known to us all that future events will become present and then drift off into the past."

[13] Bigelow avoids committing himself fully to this view, saying, among other things, that he cannot give an argument that the right sorts of worlds exist. He seems to be primarily concerned with a modal analysis of time as a plausible research program.

Passage, then, is just the successive actualizing of future possibilities – or, possibilities which count as future because they are related in the right sort of way to the actual world – and similarly the de-actualizing of possibilities as they become past.

Actualization-type views are interesting because they seem to capture a common intuition people often have in talking about time, namely, that times, especially future times, seem to be (mere?) possibilities. But as Perovic (2019) points out, these views just replace one murky metaphor (accumulation of time-slices at the edge of a block) with another (e.g., unactualized branches "falling off", the idea of 'actualization' itself). Moreover, the actualization-type theorist needs to spell out whether possibilia should be thought of as existent or not — that is, whether or not these views require modal realism (where possible worlds do exist in a metaphysically substantial way but are simply not the actual world). For, if they do embrace modal realism, they inherit all the standard objections to that view, with added complications of explaining how substantial other worlds "replace" the current actual world when they actualize. And, if they do not embrace modal realism, then on a standard non-realist view of possible worlds, these times-as-possible-worlds are just (maximally consistent sets of) propositions, making this view either worryingly metaphysically lightweight (the past and present amount only to sentence tokens) or heavily in need of further explanatory framework (to explain how abstracta can become concreta, as when abstract sentence-types or propositions "actualize").

2.2.4 Succession-type passage

If substantivalist hypertimes, magic growing blocks, and modal realism are all too worrisome to take on, perhaps the last type of account of passage, succession-type passage, will offer a less metaphysically suspicious route. On this kind of view, temporal passage is taken to simply be the fact that one event (call it Y) follows after another (call it X), perhaps along with the fact that this relation of succession is not symmetrical — that is, Y follows X, and X does not follow after Y.

This is the view of Savitt (2018), a B-theorist who holds himself to be a dynamic theorist

because he accepts the reality of this type of passage.[14] Passage, as he has it, is the successive occurrence of sets of simultaneous events — for, he says pithily, "Isn't that *[e.g., succession]* exactly what clocks measure?"

Savitt locates this succession-type passage locally (along so-called "timelike" world curves, that is, on individual world lines in spacetime) rather than globally (across a hypothesized global simultaneity plane) in an attempt to locate real passage in a relativity-friendly way: the passage of time is thus just the succession of points along a timelike curve. But because such an account would mean that, counterintuitively, none of us share a "now" or a present, since each of our worldlines will be distinct, Savitt offers a further story which appeals to the succession of "causal diamonds" rather than points. Causal diamonds are regions on a timelike curve which are temporal intervals (i.e., the boundaries of these regions are some number of seconds apart). Specifically, these regions represent the intersection of a future light cone from some point e with the past light cone of some point in e's future, e'. If you can imagine these two light-cones, one pointing "forward" (towards the future), the other pointing "back" (towards the past), their intersection will form a diamond.

If the specious present (the present which we experience; the duration which seems to be *now* phenomenologically), which has been measured to be somewhere between 0.5 seconds and 3 seconds in length, is taken as the interior of such a diamond, Savitt suggests that such a diamond could perhaps explain the experience of sharing a present with other people. This is because, on a Minkowskian model of spacetime, where space and time are inseparably integrated, a causal diamond consisting of an interval of one second of time is 300,000 km wide at its waist; a diamond consisting of two seconds of time is 600,000 km wide. Savitt points out that until very recently in history, such distances would be vast, and it would be unsurprising for them to be thought of (experienced as?) global — the diameter of the entire Earth, through its center, being only 12,796 km. Such a diamond would still be local (tied to

[14]This is also the view of R. T. W. Arthur, whose 2019 *The Reality of Time Flow* sets out an extremely similar view to what is described below: "Passage, I have argued, is local: events come to be out of other events in their neighbourhoods, and processes are constituted by such successions of events or states of a system undergoing evolution." (p.264)

a timelike curve), so would not truly completely overlap with another diamond on another timelike curve (i.e., one person's specious present, represented by a given diamond, would not perfectly overlap with another person's specious present). Nevertheless, Savitt says they could *nearly* completely overlap, if the worldlines and the beginning and end points of the diamonds are close spatially, so for all practical purposes, they would seem shared on any coarse-grained inspection.

The problem, on a typical dynamic view, is that this probably can't be the whole story, even locally. If some diamond X and some other diamond Y have both always existed, and also have always occurred in that particular order (that is, they have always stood in the same relations to each other), then nothing has changed in the sense that we are after, the sense which maps to our experience as of change; this is not really any different than the static "at-at" view of change which typically involves points. To use what will later become a very familiar analogy: given two successive pages in a book, the fact that one follows the other doesn't imply that anything is changing (unless, of course, the pages are flipped). On the other hand, if X and Y have not always existed, or if X and Y have not always had the same relations, we might have more to tell; but it seems then we will have to tell a story about passage as becoming (meaning times coming into existence, or entities beginning to instantiate properties), or passage as the actualization of possibilia, etc. – that is, to adopt some other account of passage – *or* to reject the idea that times are like static pages in a book or defined regions on a tapestry (or spacetime manifold, as it were).

2.3 Why believe in passage at all?

Before deciding whether any of these accounts of passage hit the mark, though, we ought to take a step back and ask what all these accounts are after, so we know what mark we are aiming at. We have been taking it for granted that there is a natural or "folk" presumption in favor of belief in passage, and looking at accounts that purport to offer philosophically defensible and developed characterizations of that passage. But if we want to know what "the

passage of time" is supposed to track when people talk about it, we might ask on what basis people form the belief that time passes. This is not to suggest that there is some uniform concept of temporal passage that all people share, nor that, if there was such a universally shared concept, that it would necessarily track real features of the physical world. But it likely provides us with some useful data, since most, if not all, of both science and philosophy would be useless if we did not think that our concepts were shared to at least some degree and that many of those concepts do track some feature of reality.

So: why do people believe in passage in the first place?

I will start with the fairly underwhelming suggestion that they believe time passes because they believe they have the experience of time passing. This is not just the experience as of seeing the hands on a clock move, but the immediate and ubiquitous experience we have as of things changing. We see not just that the clock has changed position, but that the cat has gotten up from its mat and wandered over to the window; we recognize that we've now read a third of our book; we hear the church bells ringing out noon; we smell that something we put in the oven is nearing completion; we introspect and watch our thoughts dart from topic to topic like a bee alighting on a series of flowers. We long ago as a species set up calendars and sundials and clocks to track these changes, and we say that these devices mark the passage of time because they mark, not the individual changes themselves, but rather the abstraction we make from such changes, that is, that *things change*.[15] It is the fact that things change that causes us to say that time has passed; more accurately, it is the fact that we perceive things changing, our phenomenology as of change, that causes us to believe that time is passing. Accordingly, our understanding of passage is bound up with change, and involves an inferential move from change to passage.

So there is phenomenology as of change backing our belief in passage, and there is a metaphysical argument contributing to that belief which links change to passage. Let us examine that argument.

[15]That is, clocks do not measure the passing of, e.g., December 7th, 2023 specifically, but of all Decembers in all years.

2.3.1 The Argument from Change

The argument which underlies the common understanding of time's passage seems to go something like this:

1. Things change.

2. If anything changes, then time passes.

3. Therefore, time passes.

Indeed, all of the accounts of passage we've examined involve change as a central component. The motion of times against a hyperplane is a change which happens to times. The accumulation of times at the edge of a growing block is change which happens to the block universe, namely, a change in size. The actualization of possibilia is a change in what things are possible. Even the succession account relies intrinsically on what we'll see in a moment is the classic at-at view of change as interpreted in a static theorist light: all it needs for change (and therefore for passage) is for there to be an ordered succession of distinct times. And, though I declined to call it an "account" as such, there is also the common view of passage which we discussed in the very beginning, according to which passage is change in which entities have which A-theoretic properties. Change, it seems, is what passage hangs its hat on.

But this inferential move from change to passage requires further scrutiny. Take the first premise of our argument: things change. What is that supposed to mean? What is it to change?

On "at-at" change

Russell's 1903 *Principles of Mathematics* provided a reductive account of motion which is still widely invoked, and often used in the literature on time as an account of change more generally. This account, often referred to as the "at-at account" of motion, tells us that *necessarily, for any* x, x *is in motion iff there exist spatial regions* s_1 *and* s_2*, and times* t_1

and t_2*, such that* s_1 *is distinct from* s_2*,* t_1 *is distinct from* t_2*, and* x *is at* s_1 *at* t_1*, and at* s_2 *at* t_2.

It is reductive in the sense that it tells us that all the facts about the motion of an individual are completely determined by facts about that entity's spatial location at one time, and that entity's spatial location at another time. Since motion is a special case of change, it can be (and often is) generalized to all cases of change without too much trouble: the "at-at" account of change tells us that *necessarily, for an* x*,* x *changes iff there exists properties F1 and F2, and times* t_1 *and* t_2*, such that F1 is distinct from F2,* t_1 *is distinct from* t_2*, and* x *has F1 at* t_1*, and F2 at* t_2.[16]

This account has been widely influential upon a variety of philosophers and invoked in a variety of philosophical problems.[17] But only those who invoke it in discussion of temporal ontology or time more generally will concern us here, so I will mention a few of the illustrative ways in which it has been used.

The at-at account of change plays very nicely with the B-theoretic (static) account of time, according to which time consists of nothing more than entities (times, objects, states of affairs, events) standing in B-theoretic relations, e.g., *being earlier than*, *being later than*, and *being simultaneous with*. So, there is some object o which has some property F at some time t – the cat's being on the mat at noon – and that o has a different property F_2 at a different time t_2 – the cat's being on the bed at midnight. Per the at-at view of change, this is all that change in o consists in; per the static view of time, the event or state of affairs of the cat's being on the mat at noon is earlier than the cat's being on the bed at midnight, and that is all that time (or temporal passage) consists in (t_1 and t_2 being in an ordered succession). One could be a substantivalist static theorist, according to which one only needs

[16]In taking this to be relevant to a description of true change in an object, one likely needs to restrict the properties in question to intrinsic properties in order to avoid so-called "Cambridge change", that is, to avoid (for example) saying that there has been a genuine change in some person Pete when Pete's brother marries and Pete gains the extrinsic property of being a brother-in-law. Russell himself (1937) provided what is now called the "Cambridge criterion" for change, and a corresponding anti-Cambridge-change modification is called for by Healey (2004) in his account of change in general relativity: "A change in o means a difference in its intrinsic properties." (p.387)

[17]See, for just one instance instance, Grunbaum's 1967 *Modern Science and Zeno's Paradoxes*, who uses Russell's account of motion to dissolve, well, some of Zeno's Paradoxes.

times existing in an ordered succession for there to be time "passing" in the static sense; but because the actual world does contain objects (events, states of affairs), static theorists who hold the at-at view can infer the passage of time from the change we observe, since the at-at view of change requires that there be a t_1 and a later time t_2.

Consequently, at-at change is most commonly invoked by static theorists, such as Sider (2001), who invokes at-at change in his argument against presentism: presentism, he says, cannot account for the cross-temporal relations that are required to describe change because it cannot countenance the existence of t_1 once it is past and t_2 has become present, and so there are missing relata which would be required (assuming this account is the correct account of change).

However, as mentioned previously, the at-at account of change has wide appeal, and is sometimes wielded even by dynamic theorists; for example, Samuele Iaquinto (2019) implicitly invokes the violation of at-at change in his case against standard perdurantism, linking (somewhat unusually for a presentist) "genuine change" to "at-at change" (emphasis mine):

> Despite its undeniable virtues, perdurantism forces us to abandon our commonsense belief that there is *genuine change* in the world... Consider Alan, who is now sitting and then standing. In a perdurantist framework,this putative case of change should be described in terms of mere qualitative variations of Alan's temporal parts. The mereological sum called 'Alan' has a stage having the property of being sitting. At a later point of the sequence of Alan's stages we find another stage having the property of being standing. *Despite the appearances, no entity gains or loses properties.* In a sense, perdurantism invites us to adopt an atemporal perspective. From that perspective, reality appears to be nothing but a static whole.

Iaquinto's (common) complaint here is that, on the perdurantist view, there is no single x which has one property at one time and another property at another time, and so no change

(in any x) has taken place (at least assuming the standard formulation of the at-at account of change). For Iaquinto, "genuine change" is at-at change, that is, change *in an object*.

A critique of at-at change

Because of this intellectual inheritance from Russell, there is a broad general tendency to understand change in the at-at way, and thus it is easy for some to think that an at-at view accounts for all there is to account for with respect to passage. So, for instance, the cup is on the table at t_1, and it has fallen to the floor at t_2. The cup has changed position; following our argument from change, we can observe this and infer that time has passed between the cup's being on the table and the cup's falling to the floor. That is all that we (seem to) need to know about passage, at least *prima facie*. And that is all static theorists seem to want.

But this picture (of at-at change) only works as a sort of coarse-grained model of the world. For, in fact, it's unclear that there is any such thing as the cup, or that there are such things as the times t_1 or t_2, outside of our mental modeling of the world. Let me problematize each in turn.

Against (a certain picture of) objects

With respect to the object – in this case, the cup – I do not mean to merely point out that cups are artifacts, or to deny the existence of artifacts in at least some sense. But the cup is a collection of relatively tightly-bound particles, the interaction between which gives rise to our experience of the various properties of the cup (hardness and shape and weight and so on). Of course, there will be other particles in the vicinity of the cup, and this means that, while there is a natural way in which it makes sense to pick out the cup as different from the table and the air around it, the borders of that cup are more metaphysically vague than what we commonly perceive — consider: which particles really count as included in the cup when "viewed" (considered) at a particle level? Even if we arbitrarily impose bounds on what particles count as "particles belonging to the cup" at this level, there will

be interaction between the particles "in" the bounds of the cup and outside of it, and gain or loss of particular particles (with respect to those boundaries) going on all the time.

Moreover, the cup owes the properties with which we identify it to the passage of time. That is to say, at a very fine-grained level, if the cup is gaining or losing even a few particles over time, the cup's precise weight will change from moment to moment, beyond our capacity to perceive such. Other properties of the cup will similarly fluctuate at this level below our perception, and presumably not at the exact same time as the weight's fluctutation, since not every property will be metaphysically dependent on the same things. For example, how fragile the cup is will be (at least partially) a consequence of the density and spatial arrangment of the cup's particles, and one could imagine the exact same particles in two different arrangements resulting in "two" cups which differ in how fragile they are despite being constituted of the same matter. So while weight will depend on the mass of the cup and therefore on which particles comprise it, fragility does not depend on the mass of the cup in the same way.

So, the cup's existence, to the extent that we *can* identify the cup, is necessarily extended over time because the properties which make up the cup are temporally extended — and those properties are not necessarily extended in a perfectly simultaneous manner.

What do I mean by saying the properties of the cup are temporally extended? I mean that any physical property of the cup will take time to instantiate, because physical properties are more like loose estimates of an average over some period of time (however short). When we are in the *process* of weighing the cup, even in the most precise ways we have available, the particles that make up the cup will be in constant states of motion and change over the course of that weighing. And so on for every other sort of physical property: density, color, size, temperature, thermal conductivity, velocity, etc. Many of these are in fact explicitly defined in terms of averages over temporal extension: for instance, temperature is a measure of the *average* kinetic energy of the atoms in motion which make up some entity whose temperature is being measured. We clearly already know that temperature, etc., are not instantaneous properties, but in practice we model them as if they were so — e.g., talking of the cup's

temperature at t_1.

Nothing stands still: even at absolute zero, particles retain some vibrational motion; their lowest energy state is still a state of constant fluctuation.[18] Indeed, fundamental particles and energy fields and even vacuums are typically *defined* by these fluctuations. For example, electrons are defined by having intrinsic angular momentum (spin) – a type of motion – and by having a particular electric charge, which is itself defined in a dispositional way which also makes reference to motion: charge is a property that causes a particle to attract or repel in the presence of other charged particles (that is, a particle is charged iff it *would be* attracted or repelled *if it were* in the vicinity of another particle with charge). The negative charge of an electron manifests itself only *through* time, not *at* a time. The notion of its having a property (e.g., position, momentum) at a time is an idealization of its activity through time.

This means that at the fundamental level, fluctuation (change) is intrinsic to the nature of all physical things, right down to particles and fields; consequently, all physical properties are temporally extended. And, again, we already *know* this in some sense: we define things in this way, as we saw in the case of properties like temperature and charge, and by extension, in the way we define objects like electrons in terms of these temporally extended properties. That, in turn, means that (if we take our own understanding of science seriously) a cup is not a cup at t_1, if t_1 is understood as an instant: a cup is only a cup over an interval. That is, a cup is fundamentally a *process*. It is only our own coarse-grained models of the world that break these processes down into (apparently) component static (instantaneous) parts, but this is not what we actually find in nature when we examine it as finely as we are able.

Indeed, it's unclear how we *could* find such things in nature, even if it were the case that objects could be fully present at instants. For, note again that (for example) the weighing process is a process itself; all our observations are processes, which necessarily take place over time: observations have a beginning and an end. We therefore cannot observe a single isolated instant even theoretically, *despite the fact that we can model such instants*. Whitehead (1920,

[18]To put this another way: in post-relativistic physics, there is no intelligible physical notion of 'being (absolutely) still' or being at 'absolute rest'.

p.57) puts the point thusly:

> 'For example, we conceive of the distribution of matter in space at an instant. This is a very useful concept in science especially in applied mathematics; but it is a very complex idea so far as concerns its connexions with the immediate facts of sense-awareness. There is no such thing as nature at an instant posited by sense-awareness. What sense-awareness delivers over for knowledge is nature through a period. Accordingly nature at an instant, since it is not itself a natural entity, must be defined in terms of genuine natural entities. Unless we do so, our science, which employs the concept of instantaneous nature, must abandon all claim to be founded upon observation.[19]

Here Whitehead is (correctly, I think) stressing that we can only conceive of instants derivatively, that is, as an abstraction from what we perceive, as anything we do perceive is necessarily extended in time. Consequently, we ought to take temporal extension as fundamental, since that is the starting point – what instants are abstracted from – rather than assuming that our abstractions represent fundamental reality more truly just because they are simpler in some sense. The complaint is rather akin to the situation we would be in if people assumed that a cake were made up of slices of cake, simply because they had sliced the cake. Of course, some wholes are arguably made up of parts that are more fundamental than the whole: a tower made of Legos is, in fact, made up of individual Legos. The difference is, of course, that the slices of cake are arbitrary divisions of a more natural whole; the Legos are not arbitrary divisions, but rather the tower itself is an arbitrary construction of its parts. The question, then, is whether time is like the cake or the Lego tower. Whitehead wants to push that, since temporally extended things are what we actually find when we observe the world, and we do not find instantaneous points (or even specifically-sized temporal intervals)

[19]Whitehead uses "posited" in an unusual way which is common amongst British Hegelians; he means, roughly, 'given' — that is, "an instant posited by sense-awareness" means something like "an instant given to us by sense-awareness".

except in our own mathematical and mental models, we should *prima facie* assume that the wholes we do find are the more fundamental thing.[20]

One might complain here that there are lots of things we cannot observe even theoretically and yet we still have good reason to countenance — we cannot directly observe many of the smallest bits of the world which our best models predict (quarks and so on) and yet assuming those entities is critical to the success of our models. Here I am recapitulating standard scientific realist vs anti-realist arguments: the scientific realist says it would be a miracle if our scientific models were as successful at predicting phenomena as they are if the entities they assume did not exist, so we should take them on; the anti-realist holds that we should not be ontologically committed to entities we cannot directly observe, and offers what is commonly known as the pessimistic meta-induction: the best scientific theories of the past have often been overturned by later scientific advances, and we've no reason to think our current models will not be overturned by future science in the same way.

But my point here is not to argue for scientific realism or anti-realism, and so I won't try to adjudicate between the two. Instead, my ultimate point is that, not only can we not observe instants, but nothing physical – nothing spatiotemporally extended – can exist at an (isolated) instant, by definition. There's just no work for instants to play in our metaphysical theorizing *except* for making theorizing simpler and therefore easier to do. A mereologist who is very liberal about composition can model the world such that there are entities which consist of the Eiffel Tower and the moon, and they might have some reason to do so – after all, formalizing such an entity might make it easier to talk about the concept of such a bizarre fusion and consider the logical consequences of accepting such – but the fact that someone is able to formalize it, even if they get useful results from doing so, does not mean there is *necessarily* such an entity in point of actual fact, nor does it even provide much

[20]In a later section of *The Concept of Nature* dealing with space and our abstractions from what we observe, Whitehead says: "For example, when we speak of a point in the timeless space of physical science, I suppose that we are speaking of something in nature. If we are not so speaking, our scientists are exercising their wits in the realms of pure fantasy, and this is palpably not the case. This demand for a definite Habeas Corpus Act for the production of the relevant entities in nature applies whether space be relative or absolute." The point, I take it, is that a good, philosophically-sound scientific theory of space (or of time) should be a description of the actual physical world.

evidence for the existence of such. So even a scientific realist should not be automatically committed to everything a given physical theory seems to require as a term; we should be very cautious about reading ontology off of the math.

Against (a certain picture of) times

Which leads to the second part of my problematizing of "things change": arguably, we have no empirical reason to believe that there are any such things as t_1 or t_2, fundamentally, at least not if these times are understood as instantaneous points. Talk of points on a manifold or a timelike curve, etc., is talk of our *models* and the math we use to express those models. Surely those models and the math which undergirds those models are useful, and often very successful in making predictions about the world. But the fact that we are able to make successful predictions off a model does not necessarily guarantee that the model is perfect or that we should read our ontology off that model. We do not need models to map 1:1 onto the world in order for them to work; we only need the models to correspond relatively well in ways that are salient to the thing being modeled. This is clearly obvious in cases of things people more commonly accept as models: for instance, the Bohr model of the atom is problematic in several ways (in that it fails to predict properties and behavior of certain types of atoms, etc.) and consequently has been superceded by the quantum mechanical model of the atom, but it is still taught in beginning physics courses because it does successfully predict quite a lot. That is to say, a model is useful to the extent that it predicts what we need to predict; but it need not (and cannot) predict everything. And when we are talking about a cup falling to the floor, we do not need to understand the cup's precise boundaries and properties (if there could even be said to be such things) to predict how the cup will fall. Nor do we need to exactly precisely locate those fine-grained properties in time to do so; times t_1 and t_2 will do. And this point (about not needing models of objects or times to map entirely accurately onto the world) will hold even at still more fine-grained levels — at the level of the atom or quark, for instance. We have to draw boundaries around some things in order to mentally manipulate them.

But then what hangs on getting these things right? Why can we not just say that, roughly speaking, something we call a cup is on the table at some *interval* t_1–t_2 and on the floor at some interval t_3–t_4, and call *that* change? That may work fine for understanding things like the cup, but not for understanding time. For time cannot actually work like this if the above is correct: it's not the case that there is one object enduring through some intervals until its properties change, but rather that an object is a loose process which is constantly in fluctuation, changing its properties at various points throughout a given interval — and even trying to draw boundaries around intervals will fall to the same sort of problem as trying to delineate instants.

To elaborate, we have this understanding of an instant as a sort of simultaneity 'class' – a thin "slice" of all the states of the affairs which are simultaneous with each other – but not only do we not have any empirical evidence that there are such simultaneity classes (and Special Relativity may tell against it, at least at a global level), but worse still, even if there were such simultaneity classes, we wouldn't be able to put anything in them because objects are temporally extended and fundamentally do not exist at an instant. And certainly we do not observe them: this is what is meant by referring to the present we perceive as the "specious present", and its duration has been measured, as mentioned earlier, as lasting a couple of seconds long, depending on the observer and the specific physical context.

Similarly, if we replace instants with intervals, we are make the simultaneity class bigger, but it's unclear on what grounds: it's not as if the cup's properties change simultaneously with each other, so there is no "minimum interval" of the cup's existence — or if there are, there are only minimum intervals for each property of the cup, which have some area of overlap but not perfect overlap, and at any rate there will be still less perfect overlap with the properties of the table and the floor and the rest of the room. Any boundaries we draw of either object or time interval are arbitrary, a result of the way we have to cut up the world to make sense of it. Here I invoke Whitehead (1920, p.59, emphasis mine) again:

> Every event extends over other events, and every event is extended over by other

> events. Thus in the special case of durations which are now the only events directly under consideration, every duration is part of other durations; and every duration has other durations which are parts of it. Accordingly there are no maximum durations and no minimum durations. Thus there is no atomic structure of durations, and the perfect definition of a duration, so as to mark out its individuality and distinguish it from highly analogous durations over which it is passing, or which are passing over it, is an arbitrary postulate of thought...This is one instance of the indeterminateness of sense-awareness. *Exactness is an ideal of thought*, and is only realised in experience by the selection of a route of approximation.

That is, because any event and thus any temporal interval (what Whitehead means by duration, here) is indefinite, our attempts to draw definite bounds around it are idealizations, not representative of what we actually find in the world. Idealizations are useful for many things, but they are not germane to the attempt to describe the actual character of time.

So views of time according to which time is change, *and* change is a matter of discrete (definite) objects changing discrete properties over discrete times, will fail to capture accurately what physical time must be. It is obviously both useful and natural to model the world in such a way, but such models fail to work when the phenomenon under investigation, time, is inherently misrepresented in its component parts.

2.4 Returning to a changed Argument from Change

So what do we learn from this discussion? We perceive things changing, but we know that at a fundamental level, things are messy and change is messy, and further that times themselves are abstractions from the relatively less messy nature of what we (are able to) perceive (and then model). McTaggart famously argued from the messy nature of the language of time that there was no such thing as time; but I am suggesting, from the messy nature of the

physical universe, that there are fundamentally no *times*. Instead, processes – by their very nature temporal – are fundamental, and ontologically prior to everything else physical.

We might replace the first premise of the argument from change, then, with: Everything physical is process. That is, processes are constitutive of the (physical) things we perceive and the (physical) properties we perceive those things as having or being constituted by.

If we have so altered the first premise, then the second premise will have to be altered also, to remove reference to things and change. We might instead say: If there are processes, then time is passing.

That is because what it is for time to pass, if there are no metaphysically independent *times* to change in some way, is just for there to be processes — processes giving rise to apparent change in apparent objects, which we can then mentally model pieces of, as having happened earlier or later, or as happening now.[21] In this way, temporal passage should be understood essentially as a kind of procedural evolution.

So, our changed Argument from Change has become an Argument from Process: Given that everything physical is process, and that if there are processes then time is passing, it follows that time is passing.

That is to say, temporal passage is the fact of process. And process is all there is, in a very real sense. The things we refer to as material bodies are, as we know, spatiotemporally located, *not extrinsically but intrinsically so*; better to say they are spatiotemporally extended, and to take that quite seriously, since "extended" suggests something less extrinsic than "located". And these are not static extensions, but dynamic ones. The picture of the universe as made up of discrete, easily definable objects which "sit" in a container of spacetime, having discrete, easily definable properties changing individually at discrete, easily definable times in a binary, on-off sort of way, is useful for mentally manipulating the world, but doesn't actually take physics seriously enough.

Process is fundamental to the world: it is ontologically prior to the object and to the

[21] What I mean by 'apparent' change here is not that there is no change, but that change is process, and those processes give rise to the changes we can perceive. Then we model those perceived changes in an at-at kind of way.

property, and as such, process is the not the same as an event, as least not as I understand the word to be commonly used.[22] What I take most philosophers to mean by 'event' is a state of affairs extended over time, that is, a temporal region consisting of objects instantiating properties. But on my view, an object instantiating properties is a process, and necessarily temporally extended because it is so. There is no separating them out. We abstract objects, properties, and times from the fact of process. This is what gives rise to the appearance of at-at change. And at a coarse-grained model, at-at change is a perfectly acceptable way to mentally model change in objects. The problem is that it is simply not the way it is at a fine-grained, fundamental level. It is not *quite* that objects are extended in time, contra what I said a moment ago, but rather that objects are abstractions from process. So, everything is fundamentally dynamic. The present in an abstraction, an arbitrary slice of the universe, which is process. It does not exist in a metaphysically privileged way; but neither does the static block universe, which is instead a description of the history of process. The process that was Socrates is now a process of decomposition (or whatever follows decomposition); he's not out there in the Agora, though we can model him so.

Passage is, therefore – at least if understood in this way – a real physical feature of the universe: it is in fact constitutive of it. At-at change won't do, as a basis for understanding time *qua* change, because there's no singular thing to be *at* a time, and no singular time to be at.

2.4.1 Potential problems with a process view of passage

There are two major problems with what I've proposed here, as I see it. First, it is very difficult to get hold of what a process-first ontology looks like. Whitehead is the most famous advocate of such a view, but he is notoriously dense and difficult to understand. Neo-Whiteheadians who try to advocate for it have largely produced (forgive me) some very

[22] Whitehead (1920) talks about events in a way that seems synonymous with how I use process here, as the fundamental intrinsic unit of change, from which objects and properties are abstracted. But I do not think, in the contemporary context where subject-object ontology is still dominant, that this is the way the word is commonly understood. Also, it's worth noting that an 'event', in the physics of spacetime, often just refers to a spacetime point. This usage will become relevant in the next chapter.

questionable (at best) metaphysics. How do we correctly describe the world in terms of process, when our ordinary ways of talking seem to be hopelessly entangled in the static picture of things? Maybe we do not need to; maybe our ordinary ways of talking are satisfactory in many cases, but it seems like we are due at least some investigation if we are to recommend an overhaul of the usual way of understanding things as basic as objects and times. I would like to give a fuller story, but it may be beyond the scope of this dissertation. I do not think I necessarily need to solve every problem here, however; as my primary goal in this dissertation is to defend the view that time passes, my primary aims are negative: to show that objections to temporal passage largely miss the mark, and to show that it is possible to have a view of temporal passage – the process view – which does not inherit the same deficiencies that other views might be accused of.

Second, my argument for a process-first ontology requires that times be mind-dependent abstractions from apparent changes in apparent objects. But substantivalism holds that times are mind-independent and ontologically fundamental; so we need a further argument that substantivalism is false. To this end, I defend the opposing view, relationalism, against substantivalism in the following chapter.

Chapter 3

SUBSTANTIVALISM VS. RELATIONALISM

> "We have first to make up our minds whether time is to be found in nature or nature is to be found in time." (Whitehead, 1920)

> "Against the substantivalist's insistence that unmediated spatial relations are unintelligible, the relationist will reply that experience affords us nothing that could mediate them." (Robin Le Poidevin, 2004)

3.1 Introduction

All of the extant accounts of passage which I discussed in Chapter 2 contain the inherent assumption that there are times: times aging against a hyperplane, times coming into being at the edge of a block, times as possibilia, times as causal diamonds. Even the static theorist's "at-at" view of change involves this assumption; changes are just a matter of an object having some property at one time and a different property at another time.

Presumably this is because people think that time is made up of times, and since the theorists we've discussed are not denying the reality of time, they see no reason to deny or even question the reality of *times*.

After all, on the dynamic view, it might be thought that if temporal passage is a genuine feature of the universe – that is, if time genuinely passes – then that implies that there is an entity, time, which (loosely speaking) does something, namely, passing. And these accounts all tend to assume that the way in which that passing occurs is for time's parts – namely, times – to do something: age, accumulate, come into being, or succeed each other.

Meanwhile, on the static view, there is generally a background commitment to something like the block universe, or at the very least, the existence of spacetime, and spacetime is

supposed to have a structure, the points (or intervals or regions) of which are thought of as constitutive of times.[1]

So we have an assumption that there are times, and a variety of views about what times might be: a point or region of a spacetime manifold; a totality fact (in the sense of a fact consisting of the totality of all states-of-affairs, as above); a simultaneity class, perhaps of events; or just some sort of platonic entity or abstract primitive.

If we take on any one of these views, then we might ask further questions like: How thick or thin are times? Are they instantaneous? Is there some minimum interval which constitutes a time? Or is the answer that one can slice time however one likes, because times are abstractions?

The answers to these further questions will hang on whatever is underwriting the assumption that there are times, and will have implications for what view of passage we might reasonably adopt. In particular, the view of passage which I have recommended, where passage is understood as process, requires that we understand times as abstractions. So, in this chapter, I want to turn to just that question: do times have a mind-independent reality, or not? That is, should we be substantivalists or relationalists about (space)time?

The debate between substantivalism (roughly, for now, the view that time is ontologically independent of material bodies) and relationalism (roughly, for now, the view that time is ontologically dependent on some set of relations between material bodies) is an old and ongoing one, and it has transformed over the centuries. The classical formulation of the dispute is usually held to be the one between Newton and Leibniz about whether space and/or time are absolute or relative. More contemporary versions of the debate – that is,

[1]Note that, as the term is used in physics, a spacetime is *any mathematical model* that fuses the three dimensions of space and a single dimension representing time into one four-dimensional continuum. This means that there are multiple "spacetimes" in the physics literature, corresponding to different mathematical models of different physical configurations. Many spacetimes are given by solutions to the Einstein Field Equations (EFE); but the EFE are non-linear and thus do not always permit complete solutions without approximation in every case. (For instance, there is no known solution of the EFE for a spacetime which contains only two massive bodies, e.g., for a model of a binary star system.) Spacetimes are also generally manifolds, meaning that, topologically, they are locally "flat" (i.e., their geometry is Euclidean) near any given point on the manifold, in the same way that a given surface region of a globe seems flat locally. More will be said on the notion of a spacetime in section 3.2.5.

the debate in a post-relativity world – focus on spacetime as one entity, but still draw on similar arguments. As a result there are a number of well-worn thought experiments on each side, and it is sometimes held to be at as much of a standstill as the debates about temporal ontology. And, as with the case of temporal ontology, there is analogous skepticism about whether the dispute is merely verbal quibbling over terminology. These skeptics point at the difficulty in spelling out the difference between "space" and "matter", given contemporary physics.[2]

I begin this chapter by giving a short history of the substantivalism-relationalism debate, focusing on the dispute between Newton and Leibniz, and then explaining the turn to understanding space and time as one entity, spacetime. I then do some work exploring how contemporary authors in the debate understand their own views, focusing on the issue of how to characterize spacetime substantivalism in a fair but coherent way, which turns out to be much more thorny than it might initially seem. I argue that there are only three plausible characterizations of spacetime substantivalism, and relationalism should be taken to be the denial of all three. I briefly discuss what the consequences would be for temporal ontology and for passage if we embraced either view, and demonstrate that if we are relationalists, then only my proposed view of passage, according to which passage is change, and change is understood as process, will do. I then consider five common and influential arguments for or against substantivalism, and offer critique of each. I ultimately argue that we should accept relationalism after weighing these arguments, because accepting substantivalism commits us to the existence of an entity that is unobservable even in principle, and so requires either accepting a radical indeterminism in our physical theories or denying the Leibniz Equivalence principle. And I think that this outcome – that there are strong independent grounds to accept relationalism – is a point in favor of my view of passage.

[2]E.g., see Rynasiewicz, 1996.

3.2 A short history of the substantivalism-relationalism debate

The substantivalism-relationalism debate revolves around a single ontological question: is spacetime something *over and above* matter and its properties?

Framing the question in this way is already to take a certain kind of stance. That is, I put the question as being one about spacetime. However, the historical debate has been about space and time considered separately. In this section, I will make a very brief tour through the history of the debate about space and time considered separately, focusing mainly on the Newton-Leibniz dispute, and end with a discussion of the move to considering spacetime as one entity rather than two.

3.2.1 A brief note on Plato and Aristotle

As just mentioned, the debate is most commonly traced to Newton and Leibniz, though the issue, at least if construed broadly, has ancient roots. For instance, people sometimes attribute to Plato (via the *Timaeus*) a view like substantivalism, one which held that the creation of space and time was prior to the creation of objects (and thus space and time would be independent of objects). But, as with so many things in Plato, this interpretation is not uncontroversial, especially with respect to time; it rests on a passage in the Timaeus (37d) which reads:

> [the Demiurge] began to think of making a moving image of eternity: at the same time as he brought order to the universe, he would make an eternal image, moving according to number, of eternity remaining in unity. This, of course, is what we call "time."

There is a question in the literature about what the "This" refers to here; if it refers to number, then Plato seems to be saying that time is merely a quantification of motion, which is not unlike Aristotle's view (see below), but if it refers to the "eternal image", then Plato seems to be saying that time is a kind of *sui generis* motion, not a measure of any motion. This last is the more traditional interpretation of the text.

In contrast, people sometimes attribute to Aristotle (via book IV of the *Physics*) a view closely akin to relationalism, one which claimed that time is *just* a matter of quantifying changes of objects. Aristotle defines time as "a number of change with respect to the before and after" (Phys. 219b1–2). Coope (2005) argues that Aristotle uses the word "number" rather than "measure" here deliberately, to emphasize that time is essentially a kind of ordering (as counting is a kind of ordering) rather than (essentially) a kind of measurement. Regardless, if for Aristotle time is ontologically dependent on (changes in) objects, then it is not something that is ontologically independent of those objects, and so it is not unreasonable to attribute to him a view that, if not explicitly relationalist, is at least non-substantivalist.

Of course, much more could be said about either Plato or Aristotle's views, and obviously a number of other historical philosophers, both Western and non-Western, have had things to say about the nature of space and time. But what is noteworthy about the Newton-Leibniz debate, and the reason why the contemporary debate is most commonly traced there (without much nod at all to previous work) is that Newton effectively shifted the *framing* of the issue, such that, rather than being a purely a matter for philosophy as it might have been before, the debate is now seen as perhaps the paradigm example of a problem that cannot be solved without appeal to both the results of empirical and theoretical science and the critical analysis of the philosopher.

3.2.2 Descartes, Newton, and the Bucket Argument

The context in which Newton's views on space and time developed was in a kind of philosophical response to Descartes' views on space and motion in Book II of his *Principles of Philosophy*. Descartes held that extension and matter were identical (that is, that what it is to be a body is to be extended, nothing more or less), which implies that there can be no vacuum (unoccupied space), since that would require an extended region devoid of matter, which, on the Cartesian view, is a self-contradiction. But if matter and extension are identical, then any motion of a body is motion of space (i.e., a motion of the space the body might appear to be "occupying"), which means that the body does not change place when

it is in motion – which seems to mean that it does not move at all. Descartes dealt with this problem by defining motion (in the sense of changing place) as motion relative to other bodies – that is, something changes place when it changes relative to the location of other bodies. But Descartes also developed a definition of "true" or "proper" motion, that is, of motion in the privileged, philosophical sense, as "the translation of one part of matter, or one body, from the vicinity of those bodies, which are immediately contiguous to it and are viewed as if at rest, to the vicinity of others".[3] In this sense of motion, each body has a single motion which is proper to it, regardless of its relation to other bodies. In this way, Descartes is aiming to simultaneously reject absolute motion (that is, motion relative to an absolute space) while keeping a sense of 'proper' motion (that is, motion which is relative only to the body which moves, not to other bodies).[4]

In his unpublished *De Gravitatione* and in his *Scholium* at the beginning of his celebrated *Principia*, Newton attacked both of Descartes' views on motion vigorously, and developed his own views on space, time, and motion.[5] Newton held, contra Descartes, that not all motion could be reduced to motion relative to other bodies, and that some motion is relative to space and/or time, which are unchanging and absolute. That is to say, the parts of space can not change relations with respect to one another, and neither can the parts of time do so. Newton held it absurd to think that a part of space, which is identical to the notion of place, could 'move' out of itself (which Descartes had to hold because Descartes identified the parts of space with the matter that occupied them); he similarly argued that it was impossible for temporal locations to change their relations with respect to each other (i.e., yesterday cannot become today) and so the parts of time must be absolute and unchanging as well.

In defending the notion of an absolute time, Newton partially appealed to the grounds that the astronomers of his day needed a "relative time" and a distinct "absolute time" in their equations in order to correct for mistakes in the common method of calculating solar

[3] *Principles* II.25

[4] The idea is (I think) that the motion is 'proper' because it is relative to the body's *own* surroundings, rather than relative to something about the other bodies.

[5] The date of composition of *De Gravitatione* is unknown, but is presumably earlier than the *Principia*.

time. Newton (and most others of his day) believed (incorrectly) that diurnal rotation was uniform, a reliable measure of time. Nevertheless, Newton observed that, even if the solar day was a case of uniform motion, it was still only a contingent fact that it was so. That is, since all motion is subject to possible acceleration or deceleration, then the diurnal rotation of the Earth might not have been uniform, and indeed it is possible that there might not have been any uniform motion with which we could accurately measure time. Yet, obviously, time – understood as the duration of things – would still exist, even if there were not a reliable relative time (i.e., time relative to the rotation of the earth around the sun) to call upon in our scientific work. Newton concluded that there must be an "absolute time" which remains the same in rate, regardless of the motions of bodies.

Newton also launched a series of arguments to defend the notion of absolute space, by way of showing that there must be a distinction between relative motion and absolute motion (which would be motion relative to absolute space). The most famous of these arguments is in Paragraph XII of the *Scholium*, and it is much discussed in the substantivalism literature: Newton's Bucket.

Newton's Bucket

Briefly, the Bucket argument can be understood as follows: if one suspends a bucket full of water on a long cord which has been twisted around, and then lets go of the bucket, it will start to spin. As it begins to spin, the bucket starts rapidly rotating with respect to the water, but the surface of the water will still be flat (as it was when both water and bucket were at rest with respect to each other). But as the bucket continues to spin, the water will gradually begin to rotate as well, until it is at the same rotational speed as the bucket (and thus at relative rest with it), at which point the surface of the water will become concave, rising up the sides of the bucket. What explains the fact that the water rises up the sides of the bucket? It's clearly to do with the motion of the water, since the water only goes concave as it itself begins to rotate. But it can't be an effect of the motion of the water with respect to the bucket, because when the bucket and the water were at relative rest before

the experiment, the water was flat, and yet the water is concave when they are once again at relative rest (spinning at the same speed).

Newton anticipated that some people would try to find other things in the room or the wider world to provide a second body to which the water's rotation is relative. So he offered a second thought experiment, essentially with the same set-up, except deep in empty space: two rocks tied together with a cord, which is rotated above its center. The rocks will pull the rope taut as a result of their outward force. But if they are in empty space, then what does it mean for the system to be rotating? Rotating against what?

The conclusion Newton really wants is that the inertial effects that result in the concavity of the water's surface refute the idea that the mechanically-relevant sense of motion is either (a) motion relative to some arbitrary reference body or (b) motion relative to a body's contiguous surroundings — that is, Newton means to show that both of Descartes' notions of motion fail as candidates for the mechanically-relevant sense of motion. Instead, he advances, we need to appeal to absolute motion: that is, we need to hold that true motion is motion relative to absolute space. For, without an absolute (immobile) space, how else can we make sense of the rotation of the bucket or the rocks?

3.2.3 Newtonian substantivalism

As it happens, the view that Newton *actually* endorsed about space and time is not straightforwardly the view that is generally attributed to him. That is, the view that is now called "substantivalism" is almost universally attributed to Newton, and it's usually understood as the view that time (and/or space, depending on the topic at hand) is a substance. But in *De Gravitatione* Newton rejected the idea that absolute space and absolute time were substances, on the grounds that space and time lack causal powers; he also rejected the idea that space and time are attributes (properties), since he believed they existed even in a vacuum, in which there are no bodies which they might be properties of. He proposed instead that they were "pseudo-substances", something more like substances than properties, but not quite either.

For this historical reason, the view I refer to throughout this chapter as "substantivalism" is sometimes still referred to as "absolutism", which would seem to be a more accurate label for the view Newton actually had.[6]

What did Newton actually hold about absolute space and time? Primarily, for our purposes, that space and time were ontologically independent from (not derivative of) material bodies.[7]

3.2.4 Leibnizian relationalism

Newton's ideas about absolute space and time are embedded in his celebrated *Principia*, which his close friend and fellow philosopher Samuel Clarke defended (apparently with some help from Newton himself) and which Leibniz vigorously opposed, in a series of five letters known as the *Leibniz-Clarke Correspondence*. Within the Correspondence, Leibniz launched three distinct lines of attack on Newton's views, along with providing a sketch of an alternative view according to which time and space are relational rather than absolute. This view – Leibniz' relationalism – was perhaps most famously put in his *Third Paper* to Clark (paragraph 4; G VII.363/Alexander 25–26):

> As for my own opinion, I have said more than once, that I hold space to be something merely relative, as time is, that I hold it to be an order of coexistences, as time is an order of successions.

Leibniz held that space and time were ideal, in the sense of mind-dependent; they are abstract structures of relations which minds construct, analogous to (in Leibniz' own example)

[6]Because substantivalists often make use of a "container" metaphor in talking about time, the view is sometimes referred to as "containerism" (though usually derogatorily). Additionally, people also sometimes refer to the view as "platonism" about time, though I think this is particularly unhelpful. For one thing, it does not bear too much resemblance to what little Plato actually said about the subject, as mentioned earlier. But even if one just takes platonism to be the view that abstract objects exist, where abstract means "not having a location in space or time", then a substantivalist version of time might technically count as an abstract object (provided one does not have a view like Taylor's which requires the existence of a hyperplane to contain time itself), but it feels a bit like a category mistake to say so, as 'abstract' and 'concrete' are designations meant to apply to objects that do or do not belong to a category (i.e., spatiotemporal), not to the category itself.

[7]See the *Scholium* for the most concise layout of these views.

a family tree, which consists of a set of abstract, internal relations between people (brother, sister, father, mother, etc.) but does not exist mind-independently or "over and above" the actual people in the family being mapped.[8] (Note that an abstraction is a mind-dependent entity but it is not *nothing*. To note that the relationship of being a brother is an abstract relation is not to say that no one is actually a brother. It is to say only that you will not find a person who is a brother who does not have a sibling. The actual people in the family are prior to the relation of brotherness.)

Of the three main lines of argument against Newton's conceptions of space and time which Leibniz offered, two were theological in nature — one arguing that Newton is heretical in assuming that space is a property of God, since that would mean God had parts; the other claiming that the idea of absolute space or time contradicts the Principle of Sufficient Reason, since God would have no reason to place a created body in one place or time over another.[9] The third line of attack, however, is of continuing philosophical interest to the debate – an epistemic argument relying on the Principle of the Identity of Indiscernibles (PII) – and so deserves some further mention.

The argument from the PII

Leibniz criticized Newton's idea of "absolute velocity" (that is, velocity relative to a point in absolute space) because absolute velocity would be unobservable even in principle (since one can never empirically observe one's position in absolute space) and so if there were two moving objects with differing absolute velocity, those differences would be empirically indis-

[8]This example comes from the Fifth Paper.

[9]From his Fourth Paper to Clarke:

> I say then, that if space is an absolute being, there would be something for which it would be impossible there should be a sufficient reason. Which is against my axiom. And I prove it thus. Space is something absolutely uniform; and without the things placed in it, one point in space does not absolutely differ in any respect whatsoever from another point of space. Now from hence it follows, (supposing space to be something in itself, beside the order of bodies among themselves,) that 'tis impossible that there should be a reason why God, preserving the same situation of bodies among themselves, should have placed them in space after one particular manner, and not otherwise; why everything was not placed the quite contrary way, for instance, by changing East into West.

tinguishable. We could only describe their velocities relative to each other. Leibniz held that these indiscernible differences would then violate the Principle of Identity of Indiscernibles, since, as he puts the principle in his Fourth Letter to Clarke, "To suppose two things indiscernible, is to suppose the same thing under two names." And if there are no differences in absolute velocity, then we have no reason to suppose there is such a thing as absolute velocity.

Leibniz invokes a similar attack on both absolute space and absolute time: if there were such a thing as absolute space (or absolute time, *mutatis mutandis*) then there would be a difference between a world oriented in one way to absolute space and an otherwise-identical world oriented in another way (say, rotated 90 degrees) to absolute space. But since no one would be able to empirically tell the difference between these two worlds, the difference between them would be indiscernible, and thus to say that there could be two such worlds is to violate the PII. Thus absolute space does not deserve our philosophical commitment, according to Leibniz.[10]

3.2.5 The turn to spacetime: Einstein's reply to Mach

After Newton's *Principia* (and despite Leibniz' objections), Newtonian mechanics were widely accepted by the scientific world into the 20th century. But the unobservable nature of absolute space that had troubled Leibniz continued to trouble both philosophers and physicists. Ernst Mach launched a sustained attack on Newton's absolute space and time in his 1883 *Science of Mechanics*, arguing that Newton's positing of absolute space was a metaphysical leap that was empirically unjustified, that the Bucket argument showed only that water will tend to recede from the center of a bucket under certain conditions, not that a relationalist view cannot account for such a phenomenon, and calling for a revised mechanics that invoked only relative distances, as he understood Leibniz to be advocating for.[11]

[10]This argument has a contemporary analogue in the Argument from Leibniz Equivalence, which I discuss in section 3.5.4.

[11]Mach suggested that perhaps the forces that cause the concavity of the water's surface in the Bucket experiment are a result of the water's rotation relative to the Earth or to the fixed stars, which exert a kind of electromagnetic pull on the water.

The most well-known of the attempts to satisfy Mach's demand for such a generally relativized mechanics is Einstein's work on the General and Special Theories of Relativity. In 1905, Einstein's *On the Electrodynamics of Moving Bodies*, the seminal work which gives us the Special Theory of Relativity (STR), at last reconciled Maxwell's equations for electricity and magnetism with the existing laws of mechanics (Newtonian mechanics!) by arguing that the principle of Galilean relativity held for Maxwell's equations, not just mechanics, and as a consequence, postulating that the speed of light was fixed in all reference frames.

To elaborate: Galilean relativity, the principle which tells us that the laws of motion are the same in all inertial frames of reference (or that the laws of motion are the same for all observers that move with constant speed relative to one another, or that mechanical experiments will have the same results in a system in uniform motion that they have in a system at rest), was known to Newton, as evidenced by the fact that he distinguished a class of "relative spaces" in which any measurement of forces, masses, or accelerations would result in the same values. But Newton did not, for some reason, seem to understand that this meant that privileging one particular "rest space" (inertial frame of reference) – specifically, privileging absolute space – was unnecessary.

Einstein's insight was in seeing that Galilean relativity held for Maxwell's equations too. This means that the form of Maxwell's equations should be the same in any inertial reference frame, and since Maxwell's equations dictate the velocity of electromagnetic radiation – light – this means that any inertial observer will observe the same value for the speed of light, no matter what the velocity of the observer or the emitter of that light may be. Thus, we can hold the speed of light as a constant (in any inertial system).

Einstein then derived the Lorentz transformations (the equations that allow one to translate the location in space and time of an event in one inertial reference frame to the location of that event of another, relatively moving inertial reference frame) in a way that defined an inertial reference frame itself as one where light travels equal distances in equal time in any direction, because the speed of light is invariant. But his derivation of these transformations, keeping the speed of light constant, means that length and, importantly, time are not pre-

served in a given transformation. That is to say, keeping the speed of light invariant is only possible when two inertial reference frames disagree on the simultaneity of an event. And that means that simultaneity is itself relative, dependent on the choice of reference frame.

Hermann Minkowski, Einstein's former mathematics professor, drew on Einstein's work on the STR and reformulated the Lorentz transformations in a four-dimensional way which express space and time as one entity, now known as Minkowski spacetime. His presentation of this work in 1908, in a talk known as *Space and Time*, opened with the famous line:

> Henceforth, space for itself, and time for itself shall completely reduce to a mere shadow, and only some sort of union of the two shall preserve independence.

The motivation for combining space and time into spacetime was that, as mentioned previously, in the Lorentz transformations which Einstein used in his STR, length and time are not preserved (invariant) in any transformation. This means that, under certain conditions, different observers will disagree on the length of time between two events *or* the spatial distance between two events. So, time cannot be separated from space, because the rate at which time passes for one observer depends on that observer's velocity relative to the second observer. Minkowski, however, combined the two distances (of time between two events and space between two events) into one new invariant, a spacetime interval, which two observers would compute the same value for. A spacetime interval is made up of the distance between two spacetime points. A point in spacetime is called an event: it is specified, in a Cartesian coordinate system, by coordinates x, y, z (for its location in the three dimensions of space) *plus* the coordinate t (for its location in time). In this way, spacetime is said to be four-dimensional.

Einstein was dissatisfied, however, with these results of Minkowski's, largely as a result of reading Mach. He did not like the central role of inertial frames in STR because, just like Newtonian mechanics, STR assigns a privileged role to certain kinds of motion and to certain kinds of coordinate systems, despite the fact that only relative motions (not privileged, absolute ones) are observable, and coordinate systems are not observable. There was thus still

an "absoluteness" in his STR which did not allow for arbitrary choices of frames of reference or arbitrary choices of coordinate system. Moreover, STR did not incorporate gravity into its calculations; it was "special" because it was limited to contexts where the effects of gravity are negligible. These concerns led him to develop the General Theory of Relativity (GTR), which was published in a series of four papers in late 1915.

The GTR is generally understood as implying that gravity is an effect of the warping of spacetime by mass. The cornerstone idea is called the equivalence principle, which tells us, roughly, that observers in free fall (that is, observers who are not subject to the effects of gravity) are in the same state as observers in the inertial frames of reference described by the STR; the laws of physics cannot tell the two apart. Newton's description of gravitational motion tells us that inertial mass times acceleration is equal to gravitational mass times the strength of the gravitational field. So, if inertial mass is equal to gravitational mass (because of the equivalence principle), then acceleration is equal to (identical to) the strength of the gravitational field. In the geometry of Minkowski spacetime, the orbit of a moving body is described as a curvature in spacetime; so acceleration of that body, being equivalent to the strength of a gravitational field, can be understood as implying that spacetime curves in response to gravity.

Einstein's hope was that, in accommodating any sort of motion, accelerated or inertial or otherwise, in a unified theory of gravity, electromagnetism, and mechanics, which did not require a special frame of reference or coordinate system, but was *generally covariant* (i.e., the equations take the same form in any coordinate system), he could achieve a completely relationalist theory of motion as demanded by Mach. That is, he hoped that the GTR would rely only upon observable motions of physical bodies and their relations to each other. To take a more specific example, he hoped that he could explain Newton's bucket (or his rocks on a rope) by appeal to all the gravitational forces in the universe, instead of relying on an absolute space (or spacetime, as it were). In a conversation with relativity skeptics, he wrote of his disappointment with the inability to completely dispense with spacetime coordinates, and his view that nevertheless, the spacetime of GTR still depends upon physical quantities

that are independent of itself (1918, p.699-702):

> Instead of "real" and "non-real" we should rather distinguish more clearly between quantities that are inherent in a physical system per se (independent of the choice of coordinate systems) and other quantities that do depend upon the coordinate system. The obvious demand would be that physics should use only quantities of the first kind in its laws. History has shown that this cannot be realized in practice...
>
> Relativity theory cannot dispense with coordinates, and thus must use coordinates as quantities that are not the result of definable measurements. According to the general theory of relativity, the four coordinates of the space-time continuum can even be chosen completely arbitrarily — as parameters devoid of any independent physical meaning. Part of this arbitrariness remains even in those quantities (field components) with whose aid we describe physical reality. Only certain ones, usually rather complicated expressions, composed of field components and coordinates are measurable (i.e., real) quantities that are independent of the system of coordinates. The components of the gravitational field in a space-time point, for example, have no equivalent quantity that is independent of the choice of coordinates; the gravitational field at a certain location represents nothing "physically real," but the gravitational field together with other data does. Therefore, one can neither say the gravitational field at a location is "real," nor that it is "only fictitious."...
>
> But, while in the special theory of relativity a portion of space without matter and devoid of an electromagnetic field is truly empty (i.e., not characterized by any physical quantities), it is quite different in general relativity. There, empty space in the previous sense has physical qualities, mathematically characterized by the components of the potential of gravitation that determine the metrical behavior of that portion of space as well as its gravitational field.

But the general consensus amongst physicists is that, within the GTR, the distribution of matter only partially determines the structure of curved spacetime.[12] That is because, even under GTR, locally, spacetime is (described by) Minkowski spacetime; it is only eliminated at a global level. So, for instance, physicists generally think that, in GTR, we *can* describe a single rotating body or system, like a neutron star or Newton's rocks, in an otherwise empty universe. In a completely Leibnizian relationalist universe, this should be impossible: rotation makes no sense except with reference to an absolute space or another body, and there is no such absolute space in a relationalist universe, and no other body *ex hypothesi* to refer to. But the GTR permits us to describe a rotating body under such conditions: because there is essentially no gravity in this nearly-matterless empty universe – the gravity of the rocks (or the neutron star) is not enough to produce the forces that would be needed to account for the rotational acceleration – GTR collapses to STR (which, recall, describes motion in situations where gravity is not a significant factor), and so we describe the rotation of the star (or the rocks) against the background of Minkowski spacetime, which is curved (allowing the rotation). And GTR also collapses to STR when we try to describe a completely empty space or world; there is nothing that prevents us from modeling such a scenario, and in such a case, all that remains is the Minkowski spacetime of STR. But then what are we to make of Minkowski spacetime?

Interestingly, however, some physicists note that if we model the lone rotating body as a shell of some mass, instead of a solid sphere, and let the size of the shell increase, Minkowski spacetime is no longer necessary to explain the situation, and instead its rotation becomes wholly determined by gravity (in the form of centrifugal forces induced in the hollow of the sphere) — that is, the rotation can be explained wholly by the distribution of matter, which is what Einstein and Mach were after.[13] And some theorists, like Wheeler and Cuifollini (1995) argue that our most successful models of the *actual* universe are based on GTR, such

[12]See, for instance, the discussion of this consensus by Brown (1997), who calls the raising of the following issue "one of the shibboleths of critics of a Machian view of space-time structure".

[13]To trace the development, within physics, of this attempt to "fix" the rotating body problem, see the work of Lense and Thirring, 1918, and later developments by Brill and Cohen, 1966, and finally by Pfister and Braun, 1985.

as the Big Bang model, and these allow the local standards of inertial motion to be entirely fixed by the distribution of matter throughout space and time.

(The Big Bang model is under fire in contemporary physics, as a number of anomalies in observation have arisen which the model cannot account for without postulating certain controversial, unobservable things like dark energy, dark matter, etc. So it's important to note that I am not asserting that the Big Bang Model is correct and that this is reason for believing that the GTR is "the last word". Instead, the reason I bring it up here is because many static theorists endorse the static theory because they believe that "the best current physics" requires the existence of a substantivalist, four-dimensional universe like that described by the Minkowski spacetime of the STR. I am attributing to these static theorists substantivalism, not just four-dimensionalism, because they typically hold that Minkowski spacetime is metaphysically substantial. That is because they think, like those critics of GTR cited in this discussion, that only Minkowski spacetime can provide ground for our models of empty and near-empty worlds; and they also think, on the grounds of a kind of Quinean indispensability argument, that if we need spacetime to account for something in the laws of physics, then we should give it our ontological commitment. So my point is not that the Big Bang model is the correct model of the universe, but that the Big Bang model is absolutely plausible as a candidate for "the best current physics". It may be overturned by future physics. And I think it will be. But an appeal to the "best current physics" as a basis for our ontological theorizing, then, should recognize that the dominant model in cosmology is based on General Relativity, and thus does not *require* that we be substantivalists about spacetime.)

What all this comes down to, then, is that GTR putably provides a successful relationalist formulation of the laws of physics for the actual, contingent universe, but it is not clearly a *necessary* formulation — that is, it might allow for the description of possible worlds which are *not* relationalist, in the sense that those worlds require a spacetime which is absolute. For example, Janssen (2012) provides a thorough criticism of Einstein's GTR which has, as part of its central thrust, the accusation that Einstein's GTR only works as a fully generalized

theory if one assumes relationalism at the outset, that is, if one refuses to accept that there could be a possible world with laws that are not generally covariant.[14] As many people want the laws of physics to hold necessarily rather than contingently, the debate between substantivalists and relationalists about spacetime is far from considered settled.

But it *is* now a debate about spacetime, rather than a debate about absolute space and absolute time. As such, it has departed from the classical formulation of the debate between Newton and Leibniz which we discussed previously. I spent time explaining that classical debate because it is difficult to get a handle on without at least a rough understanding of the physics involved, and I spent time in this section explaining the turn to spacetime because the physics that underwrites the debate has evolved. Assuming we do not wish to reject the physics of relativity (and I do not), we must now explore the debate in its contemporary form. From here on out, take any mention of 'substantivalism' to mean 'spacetime substantivalism' and any mention of 'relationalism' to mean 'spacetime relationalism'. (If I mean substantivalism or relationalism in the pre-relativistic sense, I will flag that as 'classical substantivalism' or 'classical relationalism'.)

In the next section, I turn to the work of understanding what substantivalism and relationalism about spacetime are meant to be. Because there are many different articulations of these views, I offer several versions and try to isolate a 'core view' from among them. I then move in the following section to relating the identified 'core views' to our overall project about temporal ontology and temporal passage, reiterating again that my process view of

[14] Janssen p.4:

> Einstein is not proposing what I will call the strong version of the relativity of arbitrary motion. This version requires that, if two bodies A and B are accelerating with respect to one another, it makes no difference whether A or B is accelerating. Instead, Einstein proposed what I will call the weak version of the relativity of arbitrary motion. This version requires not that both cases – A accelerating, B accelerating – are the same but only that they can be accounted for on the basis of laws that hold in the same form in a coordinate system moving with A and in a coordinate system moving with B. Prima facie, the move from the strong to the weak version – from an equivalence between physical systems to an equivalence between coordinate systems used to describe these systems – may seem to take us merely from the patently false to the utterly trivial. To halt this slide into triviality, coordinate systems need to be endowed with some spatiotemporal meaning, enough, at a minimum, to define their motion with respect to one another.

passage requires relationalism to get off the ground. In the section that follows after that, I examine five major arguments which have been given for either substantivalism and relationalism. After a critical examinination of these views, I will conclude, in the final section, that we have stronger reasons to embrace relationalism than we do to embrace substantivalism. I try to show that this is a strong point in favor of my view of passage, because I think the other views of passage require at-at change in order to be made sense of, and I argue that relationalism is incompatible with at-at change. But even if someone does not agree with that claim, the work in the rest of this chapter should at least go to show that we should embrace relationalism, and so the process view of passage cannot be undercut solely on the grounds that it requires relationalism.

3.3 Substantivalism and relationism in contemporary debate

To return to the ontological question about spacetime (is spacetime something *over and above* matter and its properties?): Substantivalists answer the question in the affirmative: spacetime is an entity which exists independently of its "contents". Relationalists answer in the negative: spacetime is in some way derivative. But beyond this simple, roughshod characterization, there is much variation in the way these views are spelled out. What follows is a quick rehashing of some of the prominent characterizations of the two views in the contemporary literature, which I list in order to give some indication of the way in which the debate is commonly framed today. For, if we are to talk about spacetime substantivalism or spacetime relationalism, if we are to ask about which view we should endorse, we need to at least understand what the holders of those views take themselves to be holding.

3.3.1 Contemporary characterizations of substantivalism and relationalism

In what follows, I present a selection of characterizations of the views, taking from papers which are considered very important and thus are frequently cited (Sklar, Field, and Earman and Norton), and from some more recent work which I think do a good job of laying out the

debate in a clear manner (Benovsky, Pooley, Lehmkuhl, Romero, and Brighouse).

Sklar (1976) characterizes substantivalism as the view according to which there is an ontologically independent spacetime (or, pre-relativistically, an independently-existing space and independently-existing temporal structure (time)). He then characterizes relationalism as the view that there are only material objects (on a pre-relativistic view) or material events (on both pre- and post-relativistic views), and further, that talk about spacetime relations should not be understood as attributing features to space or time or spacetime, but rather as attributing spatiotemporal relations to material objects or events.[15,16]

Field (1984) characterizes substantivalism as the view that the physical world contains both aggregates of matter (physical objects and their spatiotemporal parts) and *also* a (non-constructed) spacetime and its spatiotemporal parts (regions). He characterizes relationalism as the view that the physical world contains aggregates of matter and their interrelations, but does not contain a spacetime over and above these aggregates and their interrelations. He notes carefully that the debate is not about the mere existence of spacetime *points*, since the substantivalist might disagree that there are points if he holds that the process of finding ever smaller regions of spacetime has a limit, i.e., that there are discrete "minimum intervals" of spacetime; and the relationalist might accept that there are spacetime points if he holds that there are point-particles and that spacetime is a construction from such, and so is able to admit spacetime points as a convenient technical shorthand. He instead frames the debate as ultimately being about whether we should accept the existence of non-fully-occupied spacetime regions, where the substantivalist says yes and the relationalist must

[15]The reason Sklar characterizes the basic physical entity as an 'event' in a post-relativistic theory is because he sees the distinction between objects and events as being that objects are 'in' space and events are 'in' time. Since the distinction between space and time is (somewhat) collapsed in a post-relativistic setting where we talk of spacetime as a single entity, all physical entities are 'in' time and are thus events: objects with their histories.

[16]Sklar also distinguishes a third position, often termed "super-substantivalism" in the literature post-Sklar, according to which there is only one fundamental substance in the world, spacetime, and everything else (including matter) is derivative from spacetime. But since substantivalism is still true if super-substantivalism is true – that is, since super-substantivalism is a species of the substantivalism genus – I will not be addressing this view (or other views derivative from the basic positions of substantivalism and relationalism) in this chapter, as my aim is only to determine whether or not there are *times* in any metaphysically substantial way.

say no (since spacetime regions are just constructions from aggregates of matter, and any spacetime region must be identical to such an aggregate).[17]

Earman and Norton (1986) define substantivalism as the view that unobservable spatial and temporal properties of matter (e.g., 'being at position x in spacetime') are not reducible to observational relational properties of matter (e.g., coinciding, being between, etc.). They define relationalism as the simple denial of this view. Accordingly, they frame the debate as being about whether we should admit observationally-indistinct states of affairs into our ontology, since we are not able to empirically distinguish between an entity's being at position x in spacetime and an entity's being at position y in spacetime *except with respect to any observable relations which the entity holds to other entities*, and yet substantivalism (as they define it) holds that these are distinct states of affairs that do not rest solely on those observable relations.

Benovsky (2010) characterizes the two views as a disagreement about whether time is like a container: substantivalists hold that time is like a container in which events and objects are placed, but which exists regardless of whether or not there are events or objects placed in it, while relationalists hold that there is no container: time is nothing over and above temporal relations between events and/or things located in it.[18]

Pooley (2013) characterizes substantivalism as the view that a complete inventory of the fundamental constituents of the physical world would include the fundamental constituents of spacetime (in addition to the fundamental constituents of material bodies). Pooley then characterizes relationalism as the view that spacetime does not exist in a non-derivative way, and that claims about spacetime are actually claims about the possible patterns of spatiotemporal relations which can be instantiated by physical bodies.

Lehmkuhl (2015) characterizes substantivalism as the view that spacetime is fundamental and/or a substance in its own right, and relationalism is the view that only material bodies

[17]I think Field should have said here that the substantivalist must admit the *possibility* of non-fully-occupied spacetime regions, since of course it might happen to be the case that no spacetime region in the actual world is not fully occupied.

[18]Benovsky is focused on time in this article and does not mention spacetime, but presumably not because he's taking a stance against spacetime considered in the four-dimensional way it is usually presented today.

are fundamental, and space and time are just abstractions from, or in some other way derive from, the relationships between material bodies.

Romero (2015) characterizes (contemporary) substantivalism as the view that spacetime is an entity with physical properties (though he notes that the nature of those properties is open to discussion), and relationalism as the view that spacetime is not an entity that can exist independently of physical objects, and is instead a system of relations among different ontological items (though again he notes that the nature of those items is open to discussion).

Both Romero (2015) and Brighouse (2018) characterize substantivalism as realism about spacetime points (or regions), and relationalism as non-realism about the same.

To summarize, then, substantivalism is characterized variably as:

- realism about spacetime points and/or regions (Romero, Brighouse)
- the view that spacetime is an entity with physical properties (Romero)
- the view that spacetime is fundamental (Lehmkuhl)
- the view that spacetime is a substance (Lehmkuhl)
- the view that the fundamental constituents of spacetime are fundamental constituents of the physical world (Pooley)
- the view that spacetime is a container which exists independently of its contents (Benovsky)
- the view that there are unobservable spatiotemporal properties which are not reducible to observable spatiotemporal properties (Earman and Norton)
- the view that spacetime is a non-constructed part of the physical world (Field)
- the view that there exists an ontologically independent entity, spacetime (Sklar)

What all these views about substantivalism share in common is the core idea that spacetime is somehow ontologically independent from other parts of the physical world. They

differ in that some of the views characterize spacetime as fundamental in some way; some of them characterize it as a substance; some of them explicitly attribute parts to spacetime (in the form of points or regions); and some of them explicitly say that the features of spacetime are unobservable.

Similarly, relationalism is characterized variably as:

- non-realism about spacetime points and/or regions (Romero, Brighouse)
- the view that spacetime is not an independently existing entity, and is instead a system of relations amongst different entities (Romero)
- the view that only material bodies are fundamental, and space and time are derivative from relations between material bodies (Lehmkuhl)
- the view that spacetime is derivative and claims about spacetime are claims about the possible patterns of relations between material bodies (Pooley)
- the view that there is no container in which physical entities are located, and (space) time is nothing over and above (spatio-)temporal relations between entities (Benovsky)
- the denial of the view that there are unobservable spatiotemporal properties which are not reducible to observable spatiotemporal properties (Earman and Norton)
- the view that the physical world contains aggregates of matter and their relational properties and does not contain a spacetime over and above those (Field)
- the view that there are only physical objects/events and talk about spacetime should be understood as attributing spatiotemporal relations between those physical entities, not as attributing properties to spacetime (Sklar)

What these views share in common is the denial of substantivalism, that is, the denial that spacetime is an ontologically independent entity. They differ in that some of them add a second thesis, and how they spell out that second thesis: some of them explicitly say

that spacetime is derivative from relations between material bodies, while others tell us how we should interpret claims about spacetime (namely, that they are actually claims about spatiotemporal relations between material bodies or about possible spatiotemporal relations between material bodies), and one asserts that only material bodies are fundamental.

3.3.2 A deeper problem with characterizing the views

How, then, given all these competing characterizations, should we characterize substantivalism and relationism? There is an appreciable difference, for instance, between saying that spacetime is an entity which has physical properties (Romero's substantivalism) and saying that there are unobservable spatiotemporal properties which are not reducible to the observable ones (Earman and Norton's substantivalism); one attributes properties to an entity, the other says only that there are certain kinds of properties. There is a difference between saying that there are only physical objects or events (Sklar's relationalism) and saying that only material bodies are fundamental (Lehmkuhl's relationalism); 'physical' and 'material' do not clearly denote the same things, since some things that are physical (part of the physical world) are arguably not material (not made of matter) – e.g., electromagnetic fields. But there is clearly some sense in which all these views are trying to track the same positions. So what are they are trying to get at? This turns out to be more difficult to say than one might think, as I will show.

We can see, from tracing the development of the debate, that substantivalism arises from Newton's view that an absolute space and an absolute time were necessary to postulate in order to make sense of some empirical observations about the world (the bucket) and in order to accord with the math necessary for the best contemporary science of his day (e.g., the need for absolute time in astronomy). Relationalism, by turns, arises from Leibniz's unwillingness to give his ontological commitment to physical entities that were unobservable even in principle, particularly since their unobservability results in the possibility of two observationally-indistinguishable worlds that are nevertheless distinct, in violation of the Identity of Indiscernibles.

Mach and Einstein both found these concerns of Leibniz to be pressing, and were further bothered by the implication of Newtonian mechanics that some states of motion, or one's choice of coordinate system, were (apparently inexplicably) ontologically privileged in some way. But Einstein's attempts to fully relativize Newtonian mechanics led to the development of the notion of spacetime, and the inability to escape the use of spacetime in certain mathematical models in our best contemporary physics, particularly in attempts to model empty or near-empty universes, has led some contemporary physicists and philosophers to hold that we should believe in spacetime as an ontologically independent entity.

So, one could try to simply define substantivalism as the "core" view that spacetime is ontologically independent of its contents. But, how are we to understand this independence? If it's understood as the counterfactual claim that spacetime would exist even if it contained nothing, we run into a problem: what things count as the contents of spacetime?

As Earman and Norton (1987) note: in every physical theory in which spacetime figures, spacetime always contains fields at every point — the matter and (particularly of concern) metric fields. (Indeed, a field is defined as a physical quantity that has a value at each point in spacetime.) And spacetime is usually thought of as a manifold of events (here 'events' meaning extensionless points) which are structured by the matter and metric fields.[19] The matter field (more properly called the stress-energy tensor field) is made up of all the matter in the universe, and tells us what physical quantities "fill in" the events.[20] The metric field (more properly, the metric tensor field) tells us, amongst other things, the temporal and spatial distance between each event.

The metric field is a way of mathematically representing things like time, distance, volume, curvature, and angle. It also represents the gravitational potential at each spacetime point — the amount of force that would be needed to move an object from a given fixed reference

[19]See, e.g., Lange (2002) for an excellent philosophical introduction to the concepts described here, and to relativistic physics generally. (But this is just one resource. Any mistakes here are mine, an attempt to quickly and roughly summarize what I've learned about spacetime over many years and from many sources.)

[20]The stress-energy tensor is a way of mathematically representing the stress, pressure, mass-energy density, and momentum density of matter. (It is sometimes also called the energy-momentum tensor.) The stress-energy tensor field is an association of a stress-energy tensor to every point (event) on a manifold. In this way, it is (part of) what structures a spacetime manifold, along with the metric field.

point to the particular point in question.

While it's easy to understand the matter field as being part of the "contents" of spacetime, it's harder to understand whether we should treat the metric field as something spacetime *contains* or as a property of (and therefore part of) the container itself. It tells us the structure of spacetime in terms of the relations between events, and in that way, seems like a way of giving us the properties of spacetime. But, as Earman and Norton note, there are some so-called "unified field theories" in which all matter is represented by a more generalized metric tensor, and if we classify the metric tensor as a property of spacetime – as a property of the container, rather than as something spacetime contains – then substantivalism would become trivial, since there would be nothing it contained: to assert the substantivalist thesis would just be to assert the independent existence of the universe itself. We would thus lose any ability to separate substantivalism from relationalism.

On the other hand, because the metric tensor is determined by the stress-energy tensor – in other words, because "matter tells spacetime how to curve" (as physicist John Wheeler famously summarized (half) of the GTR) – spacetime would not have the properties which the metric tensor specifies without the existence of the matter field, and so if the metric tensor specifies properties of the container, it does so in a relational way, not in an intrinsic way. That is to say, the metric tensor, if considered as a property of the container (rather than something contained), is plausibly derived from the matter field, and so not an intrinsic property of an independently-existing spacetime. But then what is left of spacetime? What are the intrinsic properties of the spacetime manifold itself, or its constituent events? Without either matter or metric to specify them, we can say nothing of them, and indeed the physics doesn't — this was Earman and Norton's point: spacetime always contains fields in every physical theory which features it. One could still have a bare manifold substantivalism, where the metric and matter fields are considered as contents of the manifold, not as properties of it; but then that bare manifold isn't motivated anymore by any existing physical theories, and it's unclear what we should say of it.

So now we are back to trying to understand what is meant by the ontological independence

of spacetime. As we've just seen, we could try to understand it as the claim that spacetime is not derivative from its contents, that is, from material bodies and their interrelations. But we cannot specify the metric tensor without determining the stress-energy tensor – remember, matter tells spacetime how to curve – so we cannot even begin to express or model spacetime outside of its relationship to matter.

We can try instead to understand it as realism about spacetime *points*, and say that spacetime is constituted of the collection of these points. But we'd better be careful to describe the existence of these points outside of the metric and matter fields, or we will run into the same problem as above. This cautiousness would mean we could not describe a spacetime point, or event, in terms of what we would ordinarily think of as an event: an object instantiating properties at a time. But then what is a spacetime point? Is it not just a specification of a location in spacetime? If so, we must assume the independent existence of spacetime in order to talk about spacetime points. This seems self-defeating given the present project of trying to understand what is meant by the ontological independence of spacetime, since it would be circular: we would then say that the ontological independence of spacetime is characterized by realism about spacetime points, and spacetime points are....points in an independently-existing spacetime. That is just to say that substantivalism is realism about spacetime, which isn't very helpful at all.

We can take try another strategy in our quest to understand what is meant by the ontological independence of spacetime by saying that it means that we must quantify over spacetime points in our best physical theories. But it is unclear that this helps matters: as we've discussed several times, the fact that we are capable of mathematically modeling a particular structure does not guarantee that there is anything that instantiates that structure.

We could try to say that a substantivalist spacetime's independence consists of it not being reducible to other structures or entities. This seems to be what is meant by the views of substantivalism which characterize it as the claim that spacetime is fundamental. But talk of 'fundamentality' or even 'reducibility' is murky territory. So, in the next section, I will consider a recent proposal to understand substantivalism in terms of fundamentality. While I

will have criticism of this proposal, I do think a useful characterization of substantivalism can come out of the overall re-framing. Actually, I think three useful characterizations can come out of it, once we've sufficiently disambiguated several different notions of fundamentality. We can then define relationalism as the denial of these characterizations (so as to have a substantive dispute), and from there, we will be able to explore arguments for and against the views.

3.3.3 Substantivalism and relationalism re-conceived in terms of fundamentality

Jill North (2018) has offered a re-framing of the spacetime substantivalist-relationalist debate which I think captures something important about what is at issue between the two camps. According to North, both sides of the debate ought to accept the objective reality of spatiotemporal *structure*. That is, both sides ought to accept that there are real, determinate facts about intrinsic, invariant spatiotemporal features or quantities, which are the same in all reference frames or coordinate systems: for instance, that two bodies are separated by some amount of spatiotemporal distance under a Euclidean metric, or that a given particle's trajectory is straight given a particular inertial frame of reference.

Both sides can, without giving anything up, accept that there is a distinction between frame-, observer-, unit-, or coordinate-relative spatiotemporal facts and frame-, observer-, unit-, or coordinate-invariant spatiotemporal facts. And, North says, the structure of the world that anyone ought to accept is the structure that is needed to support the laws of physics. For instance, Newton's first law of motion, which tells us that objects behave differently if they are travelling inertially or not, presupposes (and thus requires) a difference between inertial motion and accelerated motion. Consequently, assuming Newton's first law is correct, a correct description of the world's spatiotemporal structure should distinguish between inertial and non-inertial motion; there must be objective facts about whether or not an object is travelling inertially.

Here North invokes what she calls *the matching principle*: a theory-choice-guiding principle which tells us that there should be a "match" between the structure of the physical

laws and the structure of the world. That is, we should prefer the theory whose described structure most closely matches what the laws of physics tell us the world must be like in order for those laws to hold.

North acknowledges, however, that no methodological principle can provide conclusive inferences, since we cannot be sure we've got the laws right in the first place. She gives the example of Special Relativity: since Einstein's derivation of the Lorentz transformations do not preserve temporal length when moving from one reference to another, we can (she says) reasonably infer that the world does not contain a frame-independent simultaneity relation. The reasonableness of this inference holds despite the fact that we can't be certain about it – there are, after all, certain theories of quantum mechanics which give us *some* reason to think we might end up needing an absolute simultaneity relation – but because it is a successful inference, in the sense that multiple empirical experiments which operate under the assumptions of STR have had success in predicting physical phenomena, we tend to think we need special reason to disregard it. All things equal, then, she argues that we should prefer a match in structure between the laws of physics and our views about the world.

What does "a match in structure" amount to? North argues that since the laws of physics often presuppose a particular spatiotemporal structure (by way of mentioning it directly or containing spatiotemporal facts as terms in their formulations), we should countenance the spatiotemporal structure required for the laws; therefore, we should be committed to spatiotemporal structure in general. [21]

This matching principle is not, she stresses, the same as Quine's criteria for ontological commitment, which tells us that we should be committed to whatever values the variables of our theories must range over in order for those theories to be true. Instead, the matching principle is meant to be about what structure we are committed to, which is not necessarily

[21]But if by the laws "presupposing a particular spatiotemporal structure", she means that we should assume that every structure described by the laws of physics is physically realized, this is to beg the question in favor of the substantivalist already. I think she does not want to do this (since she says repeatedly that both relationalists and substantivalists can countenance the reality of spatiotemporal structure) but I am worried that she is doing it unintentionally. She does not clarify what she means by 'spatiotemporal structure', except to say that it "has to do with the invariant features or quantities, which are the same in all allowable reference frames or coordinate systems." (p.6)

the same thing as a principle about what entities we should be committed to. For instance, a substantivalist and a relationalist might both accept a given spacetime structure, but hold that there are different bodies/entities in the world from which that structure derives: the substantivalist might hold that there are substantial spacetime points which function as the relata of the structural relations, while the relationalist holds that there are only material bodies which can serve as relata. Vice versa, two people might both hold that the same entities exist, and yet differ on the relevant structure between those entities: two substantivalists, for instance, might both agree on the existence of spacetime points, yet hold that those points are arranged differently, e.g. in a Galilean (relativity-respecting) way or in a Newtonian absolutist way.

Consequently, we can see that both the substantivalist and the relationalist can (and should, according to North) countenance objective facts about spatiotemporal structure.[22] Where they will differ, then, is what *grounds* that spatiotemporal structure — what that spatiotemporal structure holds *in virtue of*. The substantivalist will say that spatiotemporal structure is a fundamental feature of the physical world, not grounded in physical bodies; the relationalist will say that spatiotemporal structure *is* grounded in (properties of, or relations between) material bodies. The debate, in North's view, is really about whether bodies are more metaphysically fundamental that the spatiotemporal structure itself.

I do not think grounding talk helps clarify anything, here or in general. I agree with Wilson's famous 2014 takedown of the notion, where she argues decisively that grounding is too vague a notion to do any real work, and that instead a variety of more specific relations (e.g., type-token identity, set membership, the mereological part-whole relation, the determinable-determinate relation, etc.) are required to explain metaphysical (in)dependence. Nevertheless, I think North is on the right track in at least some sense. She is shifting the terms of the debate from being about an existence question (does spacetime exist independently?) to being about fundamentality (is spacetime more fundamental than its contents?),

[22]Note that North does not say that this is *all* they should countenance, which is what differs her recommendation from an endorsement of (any of the usual forms of) spacetime structural realism.

and I think this shift both captures the spirit of the debate and also sidesteps various ways in which the debate had stagnated over the centuries (in disputes about the meaning of "substance", "material/physical", and the like). No relationalist, as Teitel (2022) notes, is really denying that spacetime exists *in some sense*; they are just holding that spacetime's existence is derivative – non-fundamental – in some way, whereas the substantivalist is holding that spacetime is fundamental. But if we are to frame the debate in this way, I think it is crucial to settle on a notion of fundamentality that will adequately capture the essence of the two positions. Below, I will discuss some useful characterizations of different notions of fundamentality and show how they might be applied to help articulate what's at stake here.

Notions of fundamentality

Morganti (2020) has written a two-part article on the notion of fundamentality, which makes note of the many and varied ways in which something is said to be metaphysically fundamental. And while some authors (most notably Fine (2001) and Wilson (2014), despite their being at odds with each other on the issue of grounding) assert that metaphysical fundamentality is a primitive about which nothing more can be said, nevertheless, Morganti notes, it is usually characterized in terms of other notions. Fundamentality is appealed to whenever two entities are described in a relationship where one is *reducible* to the other; when there is talk of *ontological independence*; when there is talk (however loose) of *grounding*; when there is appeal to Lewisian "naturalness"; when people talk of "all that God had to bring into being" for the world to exist as it is.

Perovic (2016) has argued persuasively that there are (at least) three distinct senses of metaphysical fundamentality, which are too often run together[23]:

1. *Constitutive fundamentality* – An entity e is constitutively more fundamental than entity e' iff e is a constituent of e', where constitution is construed broadly, to include mereological and non-mereological forms of constitution.

[23]Note that Perovic is not discussing fundamentality in the context of this debate, but in the context of an issue about whether particulars, universals, or states-of-affairs are more fundamental. Nevertheless, I think her distinctions here are generalizable and useful in a variety of contexts.

2. *Explanatory fundamentality* – An entity e is explanatorily more fundamental than entity e' iff the definition or a characterization of the ontological role of e' cannot be done without reference to e, whereas e is either taken as an explanatory primitive or it can be characterized independently from e'.

3. *Existential fundamentality* – An entity e is existentially more fundamental than entity e' iff e' cannot exist without e, whereas e can exist without e'.

We see in this tripartite characterization the other notions of fundamentality well-captured and distinguished from one another — for instance, when reducibility is invoked, we often have a notion of constitutive fundamentality in mind; when grounding (and the attendant "in virtue of" relation) is invoked, it is usually doing the work of explanatory fundamentality; when ontological independence is invoked, it is usually an appeal to existential fundamentality. However, it is worth noting that these are characterizations of *relative* fundamentality – that is, all of these notions of fundamentality are case in terms of one entity's being more fundamental than another. These are not, then, characterizations of absolute fundamentality; but I offer the following extension of these characterizations in order to build a notion of absolute fundamentality:

> *Absolute fundamentality* – An entity is absolutely (constitutively, explanatorily, or existentially) fundamental iff there is no other entity which it is relatively less (constitutively, explanatorily, or existentially) fundamental than.

It would be more difficult, I think, to capture a notion of 'being equally as fundamental as' given the relative characterizations of fundamentality here, but if one has a pluralist view according to which it is possible for more than one thing to be absolutely fundamental – perhaps objects and properties, or even spacetime and material bodies – one could at least plausibly hold that two things which are absolutely fundamental are equally fundamental.

Which notion of fundamentality, if any, might we assign to spacetime to make sense of substantivalism? Given the concern about characterizing spacetime's ontological indepen-

dence, it seems natural to point to existential fundamentality: the substantivalist claim that spacetime is ontologically independent can be construed as a claim that spacetime can exist without material bodies — but given Perovic's relative characterization, it would need to add the claim that bodies cannot exist without spacetime, in order for spacetime to be considered *more existentially fundamental than* material bodies.

There are some spacetime substantivalists who want to go this route – so-called "super-substantivalists" – but they are in the minority. Instead, I think, most spacetime substantivalists would want to assert that spacetime is absolutely existentially fundamental – that is, that there is no other entity without which it cannot exist – *and* that it is equally as existentially fundamental as material bodies.

But this leads us to the same problem we started with, because it is hard to understand the claim that there are no other entities without which spacetime could not exist except as the modal claim that spacetime could exist independently of its contents. And if we take spacetime to always have at least a metric field as part of its contents – at least according to our best physical theories, which are after all the only reason for positing an unobservable spacetime in the first place – then this claim seems clearly false.

So, can we make use of a different notion of 'fundamental' here? If it's true that spacetime is always described as containing the metric field at a minimum, then it seems we cannot be after (either absolute or relative) explanatory fundamentality. For, there would be no case in which spacetime could be explained without reference to any other entity.

What about constitutive fundamentality? To assert the relative constitutive fundamentality of spacetime over the metric field would be to assert that the metric field is a constituent (in some sense) of spacetime. So far, so good. What about the case of material bodies? Can we assert that matter is a constituent of spacetime (and so is less fundamental than spacetime)? In the case of matter represented by a generic metric field of the sort found in unified field theories, perhaps. It is less clear outside of unified field theories what this would mean. But even if it's true, it's not clear that this buys us the kind of ontological independence that substantivalists want. For to say that matter is a constituent of spacetime sounds very much

like saying matter makes up spacetime. It's unclear that a relationalist would want to deny that.

So it really does seem that what is needed to make sense of the substantivalist view is the notion of existential fundamentality. But given the considerations we've discussed above, I think that the spacetime substantivalist is committed to one of the following three options[24]:

1. *Bare manifold substantivalism* – Accepts the absolute existential fundamentality of spacetime, which implies that the bare spacetime manifold could exist independently of the metric and matter fields

2. *Super-substantivalism* – Accepts the relative existential fundamentality of spacetime, according to which spacetime is not existentially dependent on material bodies, but material bodies are existentially dependent on spacetime (could not exist without spacetime, usually because they are somehow a property of spacetime)

3. *Mutual-dependence substantivalism* – Accepts that spacetime and material bodies are mutually existentially fundamental, that is, that each depends for its existence on the other

Bare manifold substantivalism faces the problem that none of our physical theories characterize the bare spacetime manifold outside of the metric and matter fields, and it is unclear what such a characterization would even look like, or why we should even believe in the spacetime manifold outside of the success of the physics that mentions it. Super-substantivalism faces the problem of explaining how it is that matter is a property or consequence arising from spacetime. Mutual-dependence substantivalism faces an intelligibility problem: unless

[24]I am here offering my own characterization for these views in terms of the notion of absolute fundamentality which I offered above (extended from Perovic's relative notions), but at least the name 'super-substantivalism' is already found in the literature (e.g., Lehmkuhl 2018, Calosi and Duerr 2021, etc.). And I think a great many substantivalists have something like bare manifold substantivalism in mind, though they do not spell this out as directly as I've done here. (I'm not sure whether anyone holds anything like mutual-dependence substantivalism.) The literature where these views are found generally just talks of the 'fundamentality' of spacetime, without any disambiguation of that notion. What I am trying to contribute here is a more precise characterization of each, indicating what kind of fundamentality is (or should be) meant.

we are to take it that matter and spacetime are identical, it's hard to understand how two things could be mutually *existentially* dependent. But I am open to suggestions here: it may just be my own failure of imagination rather than a problem for the view.

I do not think that these are completely insurmountable hurdles, but they are clearly less than attractive options. Still, given all our previous discussion, without one of these options, I am unsure how to characterize substantivalism in any other way that still permits the substantivalist-relationalist debate to be an intelligible one.

To be as charitable as possible to both relationalism and substantivalism, then, I will hereafter take spacetime substantivalism to consist in at least one of these three views, and spacetime relationalism to consist in the denial of all three views: that is, relationalism is the denial of bare manifold substantivalism *plus* the denial that material bodies are existentially dependent on spacetime. This is as close as possible to the 'core view' of relationalism we observed before – the denial that spacetime is an ontologically independent entity – without saddling relationalism with further claims about what sorts of things *are* absolutely fundamental, or how we must interpret spacetime talk.

3.4 Substantivalism, relationalism, and temporal ontology

Because this chapter is rather long, and it may be hard to keep all of the moving pieces in mind, I'd like to take a moment to redirect the reader's attention to the overall purpose of investigating the substantivalism-relationalism debate in the first place. In Chapter 1, I argued that the best way to understand the debate over temporal ontology is to construe it as a debate about temporal passage. In Chapter 2, I argued that the best way to understand temporal passage is in terms of a primitive unit of change, which I called *process*. But I also noted that the process view of passage requires relationalism to work, because it requires that times be mind-dependent entities. So we are investigating whether there is good reason to be a relationalist or not, since the process view stands or falls with relationalism.

But even aside from the process view, at least one of the other views of passage (the

hyperplane-type account) is explicitly committed to substantivalism. I suspect others are implicitly committed to one or the other view as well. And yet, there is almost no crossover between the literature on temporal ontology and the literature on substantivalism-relationalism. So it seems worthwhile to me to briefly make some connections between the two: to ask whether holding substantivalism or relationalism commits one to this or that view on temporal ontology or on passage.

I think that, at least at first glance, either substantivalism or relationalism may be reasonably endorsed by people who hold different temporal ontologies. For instance, since spacetime exists independently of its contents on a substantivalist view, this means that the fundamental temporal relations (whatever they may turn out to be) hold only either between moments of time, or between objects and times, but not merely between objects. So, for example, if one is an eternalist substantivalist, then one can hold that the fundamental temporal relations are *earlier than*, *simultaneous with*, and *later than*, and that these hold between individual times, rather than the objects that may or may not occupy those times. On the other hand, a presentist substantivalist could potentially have the view that (e.g.) the property *being present* is not monadic but a dyadic relation; it holds between the only existing time – the present – and the objects that occupy that time. In other words, it would be identical to the occupation relation that all objects hold to times on a substantivalist view.

On the other hand, if one is a relationalist, one might be an eternalist who holds that the fundamental temporal relations obtain only between the objects that comprise the universe, and that what it is to be a point of spacetime is to be constituted by some set of bodies. Alternatively, one might be a presentist relationalist who holds that the fundamental temporal properties are monadic properties that objects have, and what it is to be present is for a given object or set of objects to have a certain property (e.g., of presentness); those properties then constitute times in a derivative way.

I have talked here in the standard terminology of the temporal ontology literature. But, following my arguments in chapter 1, perhaps I have convinced you that these varying positions are best collapsed into just two: the view which endorses what I called the "New Static

Thesis", that is, static theory, and the view which endorses what I called the "New Dynamic Thesis", that is, dynamic theory. Recall that the difference between these two is whether or not temporal passage is taken to be a real feature of the physical universe.

Does the acceptance of either substantivalism or relationalism require a particular stance on temporal passage? Consider the accounts of passage we have seen.

First, on the hyperplane-type account of passage, passage is the motion of times against a hyperplane. As we mentioned before, this type of account is explicitly substantivalist: it requires the metaphysically substantial (independent) reality of times and, further, the metaphysically substantial (independent) reality of a hyperplane, or an unchanging "absolute time", which is the background against which those times change. Notably, however, this view does not particularly play well with the modern conception of spacetime: spacetime is understood as composed of unchanging spacetime points (or intervals), which events (in the philosophical sense) are located at. Spacetime considered as a whole could potentially play the role of the hyperplane, here, but spacetime points are unchanging in a way that is difficult to square with Taylor's changing, moving, *aging* times. This is not necessarily a strict refutation of Taylor's view – one could try to maintain (classical) substantivalism but reject relativity, or perhaps just reject Minkowski's derivation of the Lorentz transformations which form the basis for STR's geometry of spacetime – but then one is faced with providing some substantial alternative account. In the case of rejecting relativity, this would mean offering an alternative account of how electromagnetism works with respect to the laws of motion, or (worse still) providing some alternative to Newton's laws of motion or Maxwell's equations for describing the behavior of electric and magnetic fields.

Second, on an accumulation-type account of passage, passage consists of times accumulating at the edge of a growing block. If the growing block is taken to be the universe, then this is essentially the claim that the universe expands, which is *prima facie* compatible with either substantivalism or relationalism about spacetime — either new events come into being and their interrelations constitute spacetime (relationalism), or new locations in spacetime come into being (substantivalism). However, the accumulation-type passage of Broad and

Tooley appears to lean towards the latter, since it is not just individual objects or events coming into being which constitute change, but new 'totality facts' coming into being, upon which change in individual objects or events in parasitic. If a totality fact is a "total state of affairs" of the world – a "slice" at the end of the block, which is not identical to its contents because change in the slice is what underwrites change in the contents of the slice – it's hard to see how these totality facts are not just identical to (sets of) spacetime points. Tooley talks about the totality facts being relativized to times, and there being a totality fact "as of" a time. So maybe totality facts and times are meant to be separate notions. But if they are, then it seems Tooley wants to countenance times as independent of the contents of the totality facts. And Broad talks about the need to have changes *of* time as ontologically prior to changes *in* time. This does not sound like a relationalist view. But if it is a substantivalist one, it is somewhat difficult to square with relativity theory, since there is no "end" of the "block" in relativistic physics – that would require there to be a global relation of simultaneity, which relativity rejects. So growing block substantivalism seems like it would have to be of the classical, pre-relativistic variety, which faces a number of vexing problems (as mentioned for the hyperplane-type account).

Third, on an actualization-type account, passage consists of the actualization (or deactualization) of possibilia. This view also seems compatible with either substantivalism or relationism, depending on how it is spelled out, in a similar way to the accumulation-type discussed above.

Fourth, on a succession-type account, passage is for there to be an ordered succession of distinct times. This view can clearly be taken up by either the substantivalist or the relationalist, since an ordering of spacetime points (or intervals) can be embraced by either view, though on the latter, these points will be derivative in some way. But all one needs for an ordering is for ordering relations to hold between whatever the points are composed of.

Fifth, there is also the common view of passage which we discussed in the very beginning, according to which passage is change in which entities have which A-theoretic properties. (Let us call this the 'simple view' for now.) Since those A-theoretic properties might be

monadic or dyadic, that is, held either by an object or event in a monadic way, or consisting of a relation between an event and a location in spacetime, this too seems compatible with either substantivalism or relationism. But in saying so, we are setting aside considerations of whether a privileged property of presentness makes sense in a post-relativistic world. As discussed in the section above about the accumulation-type accounts of passage which are found in the growing block theory, a privileged property of presentness seems to require a global relation of simultaneity which relativistic physics rejects. (There have been attempts to reconcile the two, but I will not get into those here.)

So the hyperplane-type account of passage is explicitly (classically) substantivalist, while the other views seem compatible with either substantivalism or relationalism, though the accumulation-type account seems most easily understood as a substantivalist account, and both the accumulation-type account and the 'simple view' seem incompatible with post-relativistic versions of substantivalism and relationalism.

However, I suspect all of these accounts of passage involve an at-at view of change. The hyperplane-type account and the succession-type account, at least, are explicitly committed to it. The accumulation-type account tells us that passage (which is identified as change) is just there being one totality fact at one time and a different totality fact at another time, which sounds an awful lot like at-at change. I am less certain of how the actualization-type account should be understood, given the murky nature of the "actualization" metaphor, but it does tell us that all there is to passage is the fact that which future possibilities there are is different from moment to moment. This seems a lot like a sort of hybrid between the accumulation-type account and the succession-type account, and the succession-type account, at least, certainly explicitly involves at-at change. But because the actualization-type account does not directly invoke change in its explanation of passage, I cannot be sure.

Why does it matter for our present discussion whether these accounts of passage involve at-at change? Well, if spatiotemporal locations are existentially dependent on material bodies and their relations – that is, if relationalism is true – then one cannot say that change in an entity is just an entity's having one property at spacetime location A and a different property

at spacetime location B. This is because location A and location B will be abstractions from the entity itself (and its interrelations with other entities) on a relationalist view. I am *not* saying that *any* mention of 'location A' and 'location B' should be read in a substantivalist way. Rather, my point is that *if*, as relationalism tells us, we are abstracting two spacetime locations from an entity, we are doing so on the basis of a change in that entity. The change will then be ontologically prior to the location: we could not abstract the spacetime locations without that change. So at-at change is fundamentally incompatible with relationalism: at-at change gets the direction of relationalist explanation wrong by telling us that we look at objects at spacetime locations and then abstract change, instead of telling us that we look at change and then abstract objects at spacetime locations. Any view, then, which treats change or passage in an at-at way will have to be abandoned if relationalism is true, *despite* the surface appearance of compatibility of these views with relationalism. This, in turn, means that any view which treats change or passage in an at-at way is only truly compatible with substantivalism.

I have offered an alternative view of passage, on which change (and therefore passage) consists, not of at-at change, but of the primitive *process*. But on such a view, only relationalism will do. This is because, if passage is a real feature of the universe which is identical to, or consists of, process, and objects (and thus events) are derivative from process, then times – that is, locations in spacetime – cannot be non-arbitrary, mind-independent features of the world. If process is (absolutely) fundamental, in the sense of being ontologically (existentially) prior to all else, then events and their locations are ultimately abstractions from process.

And so we have good reason to ask, in our quest for understanding passage, whether we have independent reason (that is, reason which is not dependent on a prior acceptance of a particular view about passage) for being substantivalists or relationalists about (space)time. I will argue that there is convincing evidence that we should be relationalists.

3.5 Arguments for and against substantivalism

In this section we will examine 5 arguments which are common, persuasive (to many people), and aim to show either that substantivalism is true (and therefore relationalism is false), or vice versa.

3.5.1 The Argument from Near-Emptiness

One could condense a very common strain of argument for substantivalism into the following:

1. Nearly-empty worlds are conceivable.

2. Conceivability implies possibility.

3. So, nearly-empty worlds are possible.

4. Nearly-empty worlds are only possible if substantivalism is true.

5. So, substantivalism is true.

Note that this argument is to be found in both pre- and post-relativistic literature, that is, as an argument in favor of Newtonian absolutism or in favor of spacetime substantivalism. (On the Newtonian version, we would simply replace "nearly-empty worlds" with "empty times"; the fleshing out would be a little different, but the thrust is the same.) But, since the primary motivation for endorsing Newtonian absolutism was to accord with the best empirical and theoretical science, and contemporary science has replaced Newtonian absolute space and absolute time with the four-dimensional spacetime manifold, we will focus here (and throughout) only on the arguments as they bear on spacetime substantivalism — specifically, as they bear on any of the three versions of spacetime substantivalism which we were able to plausibly define in the previous section. (This particular argument, however, only goes through for either bare manifold spacetime substantivalism or super-substantivalism; mutual-dependence substantivalism requires the existence of material objects whenever there is spacetime, and so no empty worlds are possible.)

According to this argument, it is perfectly possible to coherently imagine an entire world which contains just the spacetime manifold and one material object. If conceivability is a good guide to possibility, then such a nearly-empty world is possible. But, if there are such nearly-empty worlds, then, it is argued, substantivalism must be true, for in such a case, there are not enough material objects for spacetime to be existentially dependent on (as in a relationalist view).

You may be balking already, thinking this entirely too quick. But in fact I think it to be the basic form, *modulo* a little window dressing, of an argument which has persuaded many and which we have already seen, in our earlier discussion of why it's not generally considered the case that GTR settles the dispute between substantivalism and relationalism. That is, the GTR permits us to describe either "vacuum worlds" or worlds which contain only one object with very little gravity. And the way in which it permits us to model such empty or nearly-empty worlds is by way of the STR (which holds in cases where gravity isn't an issue), and so by invoking Minkowski spacetime. That is, in order to mathematically model such worlds – such as if we want to explain why a neutron star could be considered as spinning in an otherwise empty universe – we need to describe that world as containing a Minkowski spacetime manifold. Because of this (epistemic!) necessity for physics, it is argued that we should be committed to the existence of the spacetime manifold.

This strain of thought, as far as I can tell, is to make an argument that relies on conceivability implying possibility. That is, the thought seems to go that we can mathematically model something (a vacuum world, etc.), and therefore it must be possible, and therefore we must have some explanation of it. Since a spacetime manifold makes the model work, then the spacetime manifold must be a real feature of reality.

I am not enamored of conceivability arguments; I'm not sure I've ever seen a convincing definition of conceivability. Let us assume for the sake of charitable argument that anything we can put into propositional form which is not strictly logically incoherent is conceivable. It is then unclear to me that a mathematical model which purports to describe or explain the behavior of a rotating neutron star counts as a (logically coherent) description of a world.

How fully specified is this world? Where did the neutron star come from? Did we model the entirety of such a universe, including its beginning, which somehow resulted in the sole existence of a single neutron star? Without doing so, how do we know that a description of such a world is actually logically coherent? How do we know that the same laws of physics still hold in such a world – given that the distribution of matter must be very different, the starting conditions very different, etc. – such that the STR would still accurately describe the behaviour of objects in it? That is, I don't see why we should expect the (empirically-derived, on the basis of the actual world!) laws of physics to be *necessary*.

One answer is that we've built these laws into the description, and that is why we know they are the same in the world under consideration. This is very close to begging the question. But it gets worse still: the motivation behind the thought experiment (the neutron star, or any version of Newton's bucket, really) is to explain a certain kind of *observed* rotation, and it is argued that we cannot explain that rotation without reference to a particular kind of background (absolute space in Newton's case; spacetime in the case of the neutron star). But in the case of the bucket, we are, in fact, able to observe the rotation — and now, centuries later, able to explain it without necessary reference to spacetime. In the case of Newton's rocks-on-a-rope, or the rotating neutron star, we are *not* being asked to explain an observed empirical fact. We are being asked to *assume* that there is rotation to observe, and then explain that assumed observation. This *is* begging the question, by my lights.

Even still, say that I am wrong about question-begging. Grant that we can mathematically model such worlds, and that because we can do so without apparent contradiction, they are conceivable. It is still unclear to me that this implies metaphysical possibility. Grant that it does. Still I ask: why should this metaphysical possibility matter with respect to a description of spacetime in the actual world? The conclusion that if spacetime is required to make sense of a given possible world, then we must be committed to its actual existence seems to require actualism – the view that there are no merely possible individuals – and as such, is a heavy modal metaphysical commitment that requires further positive defense.

One might be wondering why I did not try to run this argument with empty worlds rather

than near-empty worlds. One reason is that the "empty worlds" that matter to physics – the ones that matter to the people who have put forward this kind of argument – are still fairly "full" in a philosophical sense. To elaborate: certain solutions to the Einstein Field Equations result in (a description of) so-called "vacuum worlds", which are so-called because they are devoid of matter (that is, they are solutions when the stress-energy tensor (the matter field) is equal to zero). But "vacuum solutions" still involve (the representation of) the gravitational field (which contains gravitational energy even in the absence of matter) and the metric tensor field, and they also contain the cosmological constant, which is a value given for the background energy density of space. (The cosmological constant has been thought to have a non-zero value since 1998, when it was discovered that the rate of the universe's expansion is increasing.) So, it's difficult to say that empty worlds are conceivable in any way that is appreciably different from saying that nearly-empty worlds are conceivable.

Moreover, it's unclear that these vacuum solutions represent genuine physical possibilities. As Duerr and Calosi (2021) note, the cosmological constant is currently thought to represent so-called "dark energy", about which little is understood, but one common view is that this energy is really a result of fluctuations in quantum fields, which create very short-lasting particles. This would render the vacuum solutions vacuous — they would not actually be descriptions of a matterless world.

In short: this argument is unconvincing, because the fact that one can describe a structure does not mean that the structure is, or even can be, physically exemplified. And even if we grant that it is metaphysically possible that it could be physically exemplified, it is unclear that this tells us anything about what is exemplified in the actual world.

3.5.2 The Argument from Changelessness

Another common argument for substantivalism, and indeed a related one, takes its cue from Sydney Shoemaker's 1969 "Time Without Change". An updated (post-relativistic) version of this argument can be given as follows:

1. A "freeze", either local or global – where everything in some specified area stops changing – followed by the resuming of normal change, is conceivable.

2. During this freeze, the event of "freezing" gets farther into the past as the event of "unfreezing" approaches, so time passes during the freeze — that is, in a more tenseless way of phrasing things: there is spatiotemporal distance between a freezing event and an unfreezing event.

3. Since no changes occur during the freeze ex hypothesi, but there is a non-zero spatiotemporal distance between a freezing event and unfreezing event, spatiotemporal distance is not dependent on change in objects.

4. Since this scenario is conceivable, it is possible.

5. Spatiotemporal distance is only independent of change if substantivalism is true.

6. So, substantivalism is true.

The point here is not to divorce spacetime from the objects it allegedly contains, as in the previous argument, but to divorce spacetime from change in those objects — a more focused target. And, again there is the reliance on the principle that conceivability implies possibility, but let us table that for the moment. The idea here is if one can coherently imagine the world freezing – ceasing to change – for some length of time, then time obviously can pass without change. And time without change, it is held, is only compatible with substantivalism: what it is for time to pass on a spacetime substantivalist view is for there to be a non-zero spatiotemporal interval between two events (spacetime locations). This setup obviously does not require any objects at all, since once can imagine non-zero spatiotemporal intervals in empty worlds (where 'empty' means 'matterless' but does not mean 'not containing the metric field', since the metric field is required to tell us what spatiotemporal intervals are in the first place).

This argument has many flaws: it relies on the dubious move from conceivability to possibility, it assumes that global 'freezes' are coherent (and I think they are not, since, as I

have argued, change is intrinsic to being a physical object), and it requires the static-theorist presupposition that temporal passage is properly understood as at-at change (so that all one needs for time to pass is for there to be two distinct locations in spacetime separated by a non-zero interval).

One might complain that I am now arguing circularly: there are no independently-existing spatiotemporal locations (that is, substantivalism is false) because at-at change is false; at-at change is a false view of change (in part) because there are no independently-existing spatiotemporal locations for objects to be at. But note that I am not actually saying the latter here. What I am actually saying is that at-at change requires the existence of distinct spatiotemporal locations separate by non-zero intervals, but *does not establish their existence*. So, what I am really complaining about is that, in invoking at-at change, this particular argument begs the question: it assumes the existence of distinct spatiotemporal locations (empty times) on its quest to establish their existence (to establish substantivalism as true). So this argument cannot do what it sets out to do.

3.5.3 The Matching Principle Argument

Another, more unique argument for substantivalism (or at least one that is supposed to tell against relationalism) comes from North's project of reframing the substantivalism-relationalism debate in terms of fundamentality. She points out that, when the debate is so reframed, there might still be questions about how a relationalist is able to actually explain all the spatiotemporal structure required for a given physical theory in terms of just material bodies. And she notes that she thinks a successful relationalist view will have to embrace some form of modal relationalism in order to countenance, e.g., vacuum worlds, which have no material bodies and yet have a spatiotemporal structure, and which are possible to model for both standard and relativistic physics. (A modal relationalist view would be able to hold that the spatiotemporal facts of such a world hold in virtue of facts about how material bodies *would* behave, if there were any.) I disagree that a relationalist should embark on this project, because I think the physical possibility of vacuum worlds (or even

the metaphysical possibility of such) is not established, and, as I've argued, it's not clear that even it were, it should matter to us in terms of what we believe about the actual world. But, North says, even if a given relationalist denies the physical possibility of vacuum worlds, it still may be the case that the actually instantiated relations between bodies don't suffice to explain the entire spatiotemporal structure required by physics to make predictions about bodies in our world, and if so, some form of modal relationalism will still be required.

But she admits that it's not necessarily the job of the relationalist *qua* metaphysicist to show how all the spatiotemporal structure can, in fact, be grounded in material bodies. So North is willing to grant the relationalist all the tools they need to do this, that is, to assume that they can do this. Even so, she goes on to argue that there is a higher-order problem for the relationalist which she thinks gives substantivalism the edge in the debate. Her argument is as follows:

1. The fundamental physical laws are about what is fundamental to the physical world.
2. These laws refer to, or presuppose, a spatiotemporal structure apart from material bodies.
3. For the relationalist, spatiotemporal structure is non-fundamental.
4. The matching principle (that we should prefer the theory whose described structure most closely matches what the laws of physics tell us the world must be like in order for those laws to hold) is correct.
5. Therefore, relationalism is false (and substantivalism is true).

Immediately, one might ask what the second premise means: how do the laws refer to or presuppose a spatiotemporal structure apart from material bodies? North clarifies here that she refers to the fact that the way the fundamental physical laws are generally formulated, with a term that refers directly to material bodies (e.g., the mass term of Newton's dynamics, or the stress-energy tensor of general relativity) and then either a mathematical presupposition (e.g., the Galilean spatiotemporal structure presupposed by the typical formulations

of Newton's laws) or a distinct term that encodes spatiotemporal structure separately (e.g., the metric tensor in general relativity).

Nevertheless, I do not think the relationalist should be seriously dismayed by this argument, for a couple of reasons. First, I think that the matching principle is somewhat dubious. For, it's unclear what it means to say that a metaphysical thesis (which I what I think she means by "theory" here in premise 4) "most closely matches" the description of the world set out by the laws of physics. I assume by talk of "most" she has in mind here a relative, theory-choice-guiding notion between two alternatives, not an absolute notion of which single view to choose out of the entire set of possible metaphysical views. But how are we to decide which of two views 'most closely matches' what the laws of physics say? The difference between two views is not (or not always) quantifiable, and metaphysical disputes are often about, well, meta-physical things: STR is a set of ideas coupled with math that has been interpreted as implying the existence of a four-dimensional spacetime, but that entity is not observable (empirically falsifiable), and what physics emphatically *cannot* do is tell us how to (best) interpret those models. That, I submit, is a job for philosophical analysis (even if carried out by physicists in some cases) — it's not as simple as "pick the theory that matches the physics".

Second, I think there is an equivocation on 'fundamental' throughout, and sorting out which sense of fundamentality is being employed is no easy task. Take Premise 1. Are the fundamental laws of physics about what is existentially, explanatorily, or constitutively fundamental? This is a huge question all by itself. Then again, in Premise 3, which sense of 'fundamental' is meant by saying that the relationalist denies that spatiotemporal structure is fundamental?

Earlier, we defined relationalism as the denial of all three plausible versions of substantivalism, all of which involve (either absolute, relative, or mutual) existential fundamentality. So we could try to use a notion of existential fundamentality throughout. But then Premise 1 pretty plausibly comes out false. Are Newton's Laws of Motion supposed to be taken to imply that motion is *existentially* fundamental? If not, what, besides motion, are Newton's

Laws of Motion *about*?

We can make more sense of Premise 1 if the notion of fundamentality being utilized is instead *explanatory* fundamentality. But I argued earlier that this is not the sense of fundamentality which we should use if we are going to characterize substantivalism (and therefore not the one we should use if we are going to characterize relationalism), because there is no case in which spacetime can be explained without reference to any other entities; spacetime is given by an equation that explicitly invokes the matter and metric fields. [25] So, if substantivalism can't be characterized in terms of explanatory fundamentality, and relationalism is the denial of substantivalism, then understanding P3 in terms of explanatory fundamentality is a non-starter.

So, thus far we have seen three major arguments in favor of substantivalism, all of which seem fairly implausible. The next two arguments are major arguments in favor of relationalism, which we will examine to see if they fare any better.

3.5.4 The Argument from Leibniz Equivalence

One major argument in favor of relationalism, which was given in its most notable versions by Leibniz (in the form of the Argument from the PII, which we discussed earlier) and by Earman and Norton more contemporarily, might be called the argument from Leibniz Equivalence, which goes like this:

1. The Leibniz Equivalence principle (roughly: Two model structures that are isomorphic provide equally accurate representations of the physical state of affairs) is true.

2. So, if we modeled the universe as it is, and then rotated that model by 180 degrees, the resulting two models would both equally well represent the physical state of affairs of the universe; they would not describe the universe any differently.

[25] Perhaps one could try to keep the use of explanatory fundamentality by holding that spacetime is an explanatory primitive and that its mathematical description does not count as "explaining" it; but decoupled from its mathematical description (and the consequences thereof) within physics, there seems no reason to think it is doing any explanatory work anywhere, and so no reason to hold it as explanatorily fundamental.

3. If spacetime were existentially independent from material bodies, this rotation should make a difference in the way the universe is described.

4. So, spacetime is not existentially independent from material bodies.

5. So, relationalism is true.

Note that one might, for clarity's sake, add a caveat to (2) – the two models would not describe the universe any differently unless one already assumes a background upon which they had been rotated, that is, unless one already assumes the reality of spacetime – for then one could describe the rotation with respect to the background. So, the argument assumes that the models have not left any of the total physical facts out, and then reasons that, if those facts do not necessarily include the position of rotation against a supposed background of spacetime, then any such information is unnecessary with respect to the total description of the universe. And, if there is no difference in a universe described one way and a universe described in a rotated way, then a description of the universe which contains spacetime and a description of the universe which does not constitutes a "distinction without a difference", that is, it violates the PII. This is supposed to be reason to think that spacetime is not existentially independent from material bodies — and therefore, relationalism is true.

The most obviously problematic piece of this argument is the first premise — what does the Leibniz Equivalence principle mean, and why should we accept it? Roberts (2020), noting the weight of this argument (and the related Hole argument, discussed below) in the contemporary dispute, has launched a sustained attack on it by way of attacking the Leibniz Equivalence principle. He points out that the principle, as it is commonly stated, is ambiguous between what he calls the "Weak Equivalence Principle" and the "Strong Equivalence Principle", which he puts as follows:

The Weak Equivalence Principle: Isomorphic mathematical structures can all be used with equal accuracy to describe a given physical situation (though not necessarily at once).

The Strong Equivalence Principle: Isomorphic mathematical structures can all be used with equal accuracy to describe a given physical situation, at once.

The idea here is that, if one is only holding the Weak Equivalence Principle, then one does not need to abandon substantivalism, because one could simply regard the rotation of the model as a relabelling of spacetime events. As an analogy, we could describe a given city as consisting of a "West" side and an "East" side, and we could then take the same city and reverse those labels such that a library that was formerly described as being on the "West" side is now on the "East" side. The two descriptions of the city are isomorphic – the same in all respects except for the labelling of the locations – and we can still satisfy the Weak Equivalence Principle as long as we do not try to use both descriptions *at once*, that is, as long as we don't say, when interpreting the model of the city, "The library is on the West Side and on the East Side (e.g., not on the West Side)." Similarly, we could say that a particular location in spacetime has been 'relabelled' when the universe is rotated. So, the fact that a description of the universe and a description of the rotated universe are both equally accurate descriptions does not mean, by itself, that substantivalism is false.

But, Roberts says, the Strong Equivalence Principle demands something more. It demands that, given two isomorphic structures that are meant to represent a physical situation, we should be able to use them equally accurately to describe that physical situation at once, *in the same interpretation of the model*. Otherwise, we should either consider that they are not isomorphic or else they are both inaccurate/inadequate representations (since, if one was accurate but the other was not, they would not be isomorphic anyway). To take the library example again, holding the strong Equivalence Principle when interpreting a description of the city and its rotated counterpart means that, either the 'relabelling' does not provide an isomorphism (e.g., the sentence 'Cars drive on the East side of a North-South street' is accurate on one labelling of 'East' and not on the rotated version) *or* (more relevantly for our purposes) neither description of the city is accurate — because 'East' and 'West' don't actually map to anything, independent of the entities (like the library) which occupy them. By analogy, spacetime locations don't actually map to anything, and so any description of the universe which contains statements about locations in spacetime, independent of material bodies and their relations, is inaccurate (and so substantivalism is false).

Or so the relationalist would like to have it. But Roberts argues that there is independent reason for rejecting the Strong Equivalence Principle — and since the Weak Equivalence Principle is not enough to defeat spacetime substantivalism, then the Argument from Leibniz Equivalence fails.

What is his reason for rejecting the Strong Equivalence Principle? He asks us to imagine a Lorentzian spacetime manifold with a homogeneous metric field, and which is infinite to the North, East, and West, but finite to the South, where there is an open boundary. This is, he says (and I'll take his word for it), a perfectly legitimate model of a Lorentzian manifold, and therefore can be concretely interpreted as representing some given physical situation. So, if the Strong Equivalence Principle were true, any manifold isomorphic to this one could accurately represent the same physical situation "at once". But, he says, you can describe another manifold by simply taking a proper subset of the first manifold (a 'submanifold'): translate the first manifold "up" into itself (that is, imagine the metric field moving "up" through its infinite North, leaving metric-less "space" between the finite southern edge of the metric and the open boundary in the South). The result is isometric to the first manifold; isometry means that it has been transformed in a uniform way such that the metric has not changed, and thus the distance between events in the sub-manifold is the same the distance between events in the original manifold. And yet these two do not, cannot, represent the same physical situation; they are a "whole" and a "proper part". (To offer him an analogy: the set of natural numbers and a given proper subset (say, the set of even numbers) are isomorphic, but do not represent the same things at the same time.[26])

He notes that one could still hold that the manifold and its submanifold could still be held to represent the same physical situation as long as one ignores the fact that one is a proper subset of the other, that is, as long as one ignores the bits of the submanifold that are not present in the original manifold. But he thinks that it is up to the applied

[26]And lest you think my analogy is uncharitable to him, note that he offers a similar analogy later in the paper: he says that we can imagine two singleton sets, and we can have them represent, say, a black raven and a white shoe, but we cannot have them both represent the same thing at the same time, on pain of paradox of multiple denotation.

mathematician to decide whether or not to ignore a given part of a model, and that while constructing an isomorphic proper subset of a manifold is a completely reasonable practice, Strong Leibniz Equivalence is questionable and requires some further defense rather than simply being assumed. And he adds that mathematicians use the same spacetime model frequently to represent multiple different physical situations, especially when it's unclear what it's being physically represented by the parts of the model. So, for instance, one interpretation of a given spacetime model might be that a particular constant in the model represents X, and on another interpretation of the same model, that particular constant represents Y.[27] There is just one model, which is of course isomorphic to itself, and yet it is being used to model completely different physical situations! Faced with the potential reply that this means that our spacetime models are not representationally adequate, he says that as a matter of practice, we nevertheless do use spacetime models in this way, and there is no reason to think it is illegitimate for us to do so; mathematicians, he says, should have free choice to decide whether two isomorphic structures represent the same physical situation, and they should not feel beholden to satisfy strong Leibniz Equivalence.

I admire his distinction between the Weak Equivalence Principle and the Strong Equivalence Principle, and I think he's right to make such a distinction. But I think the rest of his argument is very off the mark. The point of the Leibniz Equivalence Principle is *not* that any two isomorphic structures *must* represent the same physical situation. It was that, if you are representing a *given* physical situation, two isomorphic structures will be equally accurate in representing it (and it follows that if they are not equally accurate, they are not isomorphic). So the mere existence of two isomorphic spacetime manifolds which don't represent the same physical situation is not a defeat of Leibniz Equivalence, not even the Strong version.

The 'toy' manifolds he sets up in his paper are bare of matter, and have only the metric field. But the metric field is present and homogeneous throughout the actual universe. If we

[27] Where X and Y are meant to pick out parts of the physical world. Think here of cases like the cosmological constant mentioned previously, where it's unclear what in the physical world the cosmological constant maps to. It is necessary in the EFE to explain the expansion of the universe, but it's unclear whether it represents 'dark energy' or something else.

take *any* two descriptions of the (local) spacetime manifold, of any part of the universe, and limit their mathematical construction to just their metric field (ignoring what matter may be present), they will be isomorphic, because the metric field will be the same in each. So, we could describe the spacetime manifold local to the city park and the spacetime manifold local to the planet Venus, and if we are sticking to a description of that manifold just in terms of the metric, they will be isomorphic despite "representing" completely different physical situations. But this is not because the Leibniz Equivalence principle is false — it is because we did not *start out* to model the same physical situations! His 'counterexample', of constructing a submanifold that is isomorphic to a set which it is a proper subset of, is not a case of attempting to model the same physical situation. The only places where they do model the same physical situation will be within the bounds of what is common to the proper subset and the original manifold; so ignoring the rest is not just a decision up to the applied mathematician, but what one *must* do if one is attempting to model the same physical states of affairs. It is irrelevant what people do in actual practice: Leibniz Equivalence is not a normative principle, but instead an epistemic principle that tells us that isomorphisms have, as a consequence of being isomorphic, equal representational adequacy.

The defense of this principle seems fairly obvious: if models work to the degree that their structure is isomorphic to the structure of the world, then two models that are isomorphic in structure should be equally isomorphic to the structure of the world.

So, while I think Roberts is right to distinguish between the Strong and Weak Equivalence Principle, he does not make any plausible case that we should reject the Strong Equivalence Principle. Without such a plausible case, the principle holds, and I think the argument for relationalism goes through – unless one assumes that (2) is false because one has a pre-existing commitment to the independent existence of spacetime, which is just to beg the question, unless one has some strong independent argument in favor of substantivalism. We have not seen one here, because I have not seen one yet. That of course does not mean that there could not be such arguments. But the strength of this argument, and the more specialized version of it given below, make a compelling case for relationalism which does not rely on

merely begging the question.

3.5.5 The Hole Argument

I mentioned at the beginning of the previous section that Earman and Norton (1987) gave a compelling (and updated) version of the Argument from Leibniz Equivalence. Here, I want to present their version separately (though more briefly), as it has been much discussed, and is even stronger than the previous formulation. It is known as "the Hole Argument". Briefly (or as briefly as I can), the argument goes as follows:

1. Isomorphic spacetime models are observationally indistinguishable (because spatiotemporal positions are not observable; we cannot observe that a body is positioned at spacetime location x, we can only observe that the body is coincident with the x mark on a ruler, which is another physical body).

2. There are arbitrarily many isomorphic models which differ from each other only by a 'hole transformation'. (A 'hole transformation' is taking one spacetime manifold model, with its metric and matter fields, and transforming it into another manifold such that the matter and metric fields are redistributed differently, but only within a particular region, the 'hole'. The outside of the hole is unchanged from the original, and the transition from non-hole to hole is smooth. All the invariant properties, such as the number of particles, the distance along spatial curves, etc. – which include all the observable properties – are unchanged. Only the variant properties, such as the choice of coordinate system, and therefore "being at the origin" and the like, are changed within the hole.)

3. Since the invariant properties inside the hole are changed, the spacetime substantivalist must hold that the different models represent different physical situations. (Consider: in the original manifold, perhaps an object passes through some spacetime location (event) E within the region to be transformed. Once the hole transformation takes place, since we can change the spacetime coordinates, we can change them such that

the object does not pass through E anymore. Since E must represent something 'real' for the spacetime substantivalist, these are different situations.)

4. Therefore, the spacetime substantivalist must deny Leibniz Equivalence.

5. But no observation, and nothing about the state of the region exterior to the hole – in short, none of the laws of physics which we've used to describe the two manifolds – can tell us whether we are in a world where the object passes through E or not. (from premises 1 and 2)

6. Therefore, if you deny Leibniz Equivalence, then you must accept that our physical theories are radically indeterministic.

7. Therefore, spacetime substantivalism is deeply problematic as a metaphysical commitment, and we should reject it.

A few things: I think that Roberts was right in his distinction between Weak and Strong Leibniz Equivalence, and so I take it that Strong Leibniz Equivalence is at play here. Second, it's worth noting that Earman and Norton are explicit that the reason for (7) is not because of some commitment to physical determinism:

> "We emphasise that our argument does not stem from a conviction that determinism is or ought to be true. There are many ways in which determinism can and may in fact fail: space invaders in the Newtonian setting; the non-existence of a Cauchy surface in the general relativistic setting; the existence of irreducibly stochastic elements in the quantum domain, etc. Rather our point is this. If a metaphysics, which forces all our theories to be deterministic, is unacceptable, then equally a metaphysics, which automatically decides in favour of indeterminism, is also unacceptable. Determinism may fail, but if it fails it should fail for a reason of physics, not because of a commitment to substantival properties which can be eradicated without affecting the empirical consequences of the theory."

The most popular responses to this seemingly rather devastating argument are either to deny Leibniz Equivalence (as in Roberts 2020) or to put forward a kind of view which is often called "sophisticated substantivalism", though it comes in many flavors.[28] "Sophisticated substantivalism" generally holds that hole transformations are not legitimate, distinct metaphysical possibilities, either because (1) it is held that spacetime events carry their metrical properties essentially and so only worlds where these are preserved are metaphysically possible (Maudlin 1990), or (much more popularly) because (2) it is held that there cannot be two distinct possible worlds which do not differ qualitatively, and so two manifolds related by a hole transformation do not represent distinct possibilities, because all of the qualitative properties are the same *ex hypothesi*; and so there is no need to reject Leibniz Equivalence (Pooley 2006 most notably, but also Brighouse 1994, Hoefer 1996, Dasgupta 2011, Teitel 2019, etc.). This latter version of sophisticated substantivalism is often referred to as '(spacetime) anti-Haecceitism'.

Spacetime anti-Haecceitism seems like just a straightforward endorsement of the Leibniz Equivalence principle, so one might wonder how this is compatible with spacetime substantivalism. I think the answer is that it constitutes a denial of bare-manifold substantivalism, but in the literature on the Hole argument, distinctions between types of substantivalism are rarely discussed, as Brighouse (2018) notes. This leaves super-substantivalism and mutual-dependence substantivalism as open possibilities; Brighouse does not use my terminology, but discusses "one-category" substantivalism (i.e., substantivalism that is committed only to the existence of the manifold and nothing more, i.e., super-substantivalism) and "two-category" substantivalism (i.e., substantivalism that is committed to both spacetime and material bodies, and she further indicates that what is needed is a substantivalism that holds that spacetime is always occupied by matter and that matter is always located at spacetime locations, i.e., mutual-dependence substantivalism). Brighouse, who identifies herself as a "sophisticated substantivalist", argues that (what I have called) mutual-dependence substantivalism will always be vulnerable to Hole argument indeterminism, alongside a host

[28]The term was originally coined as a derogatory one, but the adherents of the view have embraced it.

of other problems which I have not discussed here (selcouthe indeterminism, tower collapse indeterminism, etc.). This is because it permits the distinctness of a world in which some A is at point p and some B is point q from a world where A is at point q and B is at point p.

This leaves super-substantivalism as a way out for the anti-Haecceitist, but Brighouse is pessimistic here too, holding that there is not yet a sophisticated substantivalist view that can stand up to Hole-style arguments, unless it redefines (in)determinism so radically that it is no longer recognizable. This is because she thinks that even the super-substantivalist will still have to hold that matter is a property of spacetime, and the situation in which some spacetime location A has a delta function p (where the delta function represents the emergence of matter, roughly) and some other spacetime location B has a delta function q is still a distinct situation from the one in which A has q and B has p.

The Hole argument, then, seems fairly difficult to defeat. For the substantivalist to get out of it seems to require rejecting Leibniz Equivalence, which I argued is implausible; or accepting that our physical theories are intrinsicially radically indeterministic, such that they will never be able to tell us whether a particular object is at a particular spacetime location or not. This indeterminism is not bothersome for relationalists who accept Leibniz Equivalence; the two situations are just two different mathematical descriptions of the same physical situation. And while some physical theories lead us to indeterministic results in our measurements (think quantum theory, Schrodinger's Cat, etc.), the difference is that those theories do so on the basis of experimental evidence, not on the basis of prior metaphysical commmitment.

3.6 Conclusion: Accept relationalism

Contemporary substantivalism is borne out of a theory meant to reject it (Einstein's work on relativity). It is difficult to even spell out what this substantivalism consists in, what it means for spacetime to be ontologically independent. Essentially, there is math that is interpreted as meaning there is an entity, spacetime, which is ontologically independent from

bodies in some way, because this interpretation allows us to describe possible worlds in which there are no bodies (or very few ones).

There is no reason to think there are such worlds, outside of mental abstractions, unless we embrace modal realism. And even if we do embrace modal realism, it is odd to try to assert how the laws of physics behave in such worlds, when those very same laws of physics are derived from empirical data about the actual world that we cannot have about such possible worlds — unless we import them in, which is essentially to beg the question: to assume that there is spacetime in such a world. And it is yet odder still to assume that the features of such a possible world must map to our own.

To put this point another way: Either spacetime is real and the answer to "Would the spatiotemporal relations of an empty world be Euclidean if there were objects?" is yes iff that spacetime's structure is Euclidean, but we could only find that out empirically (which we obviously cannot do since we do not have access to such a world); or spacetime isn't real and the reason why spacetime relational structures are sometimes best represented as Euclidean is dependent upon other things.

Substantivalism about spacetime also requires that we deny Leibniz Equivalence, which is a principle which seems very strongly plausible, and doing so undermines the determining power of the laws of physics, since there will be arbitrarily many cases we can construct in which the laws cannot even in principle tell us whether a given object instantiates a given property (i.e., being at a particular spacetime location).

On the other hand, relationalism – at least when considered as the denial of substantivalism – asks much less of us. It only requires that we accept that our knowledge of the laws of physics is incomplete, which we know, and that there are material bodies, which we also know (or at least neither view disputes this).[29]

There is an argument from ontological parsimony here to be made in favor of relationalism: spacetime substantivalism asks us to commit ourselves to an unobservable, independently-

[29]Super-substantivalism could perhaps be taken as disputing the existence of material bodies in some sense. But there *are* material bodies on such a view; it's only that they are emergent properties of spacetime itself.

existing spacetime, which is not required to make sense of our theories, and which has somewhat disastrous consequences for those same theories, in the form of undermining their determining power. Relationalism does not. Therefore, we should accept relationalism. Perhaps arguments from parsimony are not decisive; the universe is not required to be simple, and the fact that a theory with an extra conjunct is more epistemically likely to be false does not automatically mean that it is more metaphysically likely to be false. But when we are not talking about observable entities, we are stuck with an interpretation problem. And then the question becomes: which is worse, ignoring considerations of parsimony or accepting them? Is it worse to accept a sprawling mess that appears to commit us to all kinds of absurdities, or to assume that it is better not to be committed to absurdities? I think the former is worse.

And if I've persuaded you that we should accept relationalism, then this has consequences for our understanding of time. As discussed in the earlier section on the consequences for temporal ontology, relationalism obviously rules out any thoroughly substantivalist view of passage, such as the hyperplane-type account, and possibly the accumulation-type account (depending on how it is cashed out). It also, however, undermines the at-at view of change; spatiotemporal locations will be derivative from change, not the other way around. As a consequence, most (if not all) of the other views of temporal passage we discussed cannot stand — except for the one I proposed, according to which passage is to be identified with change, and the best understanding of change is in terms of the primitive process.

Chapter 4

ON THE PHENOMENOLOGY OF PASSAGE

> "If time flow is not to be dependent upon the existence of conscious observers in the universe, a theory or model of it must be devised upon which it is ontological rather than epistemological." (McCall, 1976)

4.1 Introduction

Suppose I have convinced you that the debate about temporal ontology should be understood as being about whether or not temporal passage is a real feature of the physical universe (Chapter 1). Suppose I have further convinced you that we should accept spacetime relationalism (Chapter 3), and that this commits us to a particular version of passage according to which passage is understood as change, which is understood further as consisting of a primitive, process (Chapter 2). You still might not accept that we should believe in temporal passage at all, even if there are plausible available versions of it — that is, you might still think that we should be relationalists, but we should be static-theorist relationalists. Since my overall aim in this dissertation is to convince you that *time passes*, in this chapter, I aim to convince you that our phenomenology gives us very strong reason to accept a dynamic theory of time.

Dynamic theorists who accept the reality of passage typically do so because they take passage to be an ineliminable feature of our experience and therefore a veridical representation of reality. They believe that because we perceive our surroundings and ourselves as being involved in constant dynamic change, such change must be a genuine feature of reality. Static theorists disagree. They believe not only that there is no such thing as the dynamic theorists' version of "passage" and "change" in the world, but that our perceptions "as of change" and "as of passage" should not be taken seriously, as presenting us with a reliable guide to how

the mind-independent reality truly is. In this chapter, I present and then challenge four of the most prominent and powerful static theorist arguments against accepting the reality of passage on the basis of phenomenology. Along the way, I make the case that we should take our phenomenology seriously in the case of passage.

First, I will present the dominant static-theoretic argument that our experiences as-of temporal passage can be best understood as cognitive illusions, analogous to illusory perceptions of apparent motion. Against this argument, I present my "Flipbook Objection" - an objection which shows how static theorists must rely on the notion of passage even while they are working to eliminate it, in order to get the very concept of illusion off the ground.

Second, I will present a more recent type of static-theoretic illusion account, known as a 'projection account', which holds that our experience as of temporal passage is an illusion generated by our projections of ourselves as unchanging beings. I will show that this argument depends upon a problematic assumption that something must endure through time in order to make sense of change. This assumption can be traced to Lewis' setup of the problem of temporary intrinsics, which I will argue is deeply flawed because it assumes that at-at change is the correct model of change, and thus has substantivalist underpinnings. Ultimately, projection accounts, too, will fall victim to the Flipbook Objection. And, as I use that objection to reply to any illusion-based account of passage, I develop it into an overall case for thinking that the phenomenology of passage is a good guide to reality: specifically, I argue that because passage is an irreducible part of phenomenology, and insofar as we accept any form of physicalism, our phenomenology is part of the physical world and thus cannot have irreducible features that are not present in the physical world. Ergo, genuine physical passage must be a necessary precondition of phenomenal passage.

Third, I will present a more radical static theorist argument which throws doubt at the very idea that we could have veridical experiences of passage at all. This argument relies on the idea that, because we do not need dynamic passage in our best physical descriptions of the world, any such passage would have to be epiphenomenal, and therefore could not affect our perceptual systems, which are physical, in any way. And, since our understanding

of passage is parasitic on our experiences as of passage, then, if our experiences cannot be veridical, we cannot use them to argue for the existence of passage. To this argument, I object both by raising doubts for the claim that our best physical descriptions of the world do not involve passage, and also by showing that our phenomenology as of passage does not need to be veridical to tell us something important about how temporal passage must be, again because genuine passage is an enabling condition of experience. So, this way of evading the demand for an error theory fails.

Fourth, I present another static theorist argument which rejects any proposed relationship between our temporal phenomenology and the metaphysics of time. The argument goes that the faulty nature of our philosophical intuitions, which are built upon experiences which are themselves restricted by the contingent limitations of our cognitive architecture, makes them an unreliable source for metaphysical theorizing. Here I address the concern about theorizing on the basis of unreliable intuitions by pointing out that there is an unwarranted leap from "intuitions are sometimes wrong" to "intuitions are always wrong", and that even our best scientific theorizing (which static theorists often point to as our guide for doing metaphysics) also relies, at least in part, on a priori intuitions.

All of these static theorist arguments aim to show that we should not take our phenomenology seriously when it comes to the metaphysics of time. I will show that their attacks on our phenomenology of passage and its implications are weak and unconvincing, and that the pull of the dynamic theorist's arguments from temporal phenomenology to temporal reality should not be underestimated. And I will additionally show that the cost of keeping one's static theory in the face of these objections is surprisingly steep: in order to do so, one must embrace dualism (or something very like it).

4.2 On whether phenomenal passage can be illusory

4.2.1 Illusion accounts of phenomenal passage

The vast majority of philosophers will allow that we phenomenally experience a world where time seems to be passing. We experience the world of change fluidly; when we watch a clock ticking, a child playing, or a bird flying through the sky, we seem to perceive a single event in graceful process, an ongoing event, not a series of independent, static stages consisting of (e.g.,) the bird's having one wing up, then flat, then down, then flat, then up, etc. Moreover, this apparent perception of passage does not merely extend to the visual. We also hear it when we listen to an orchestra playing a symphony, or sense it in the feeling of our chests rising and falling as we attend to our breathing, and so on. Richard Taylor says that we know it intimately when we know that our death is, in fact, approach*ing*. All our conscious experiences seem to feature this awareness of the apparent passage of time, which only breaks naturally into discrete, static-seeming "chunks" when we try to attend to, and then describe, whatever is "now" – "now" – and "now".

According to any static theory, these experiences, however fundamental and genuine they might seem, must be illusory; they cannot be veridical, because time is not passing. It is natural, therefore, for the dynamic theorist to demand that the static theorist produce an error theory to account for the phenomenal passage of time. In this section, I will focus on one dominant strain of static-theoretic response to that demand: arguments that our experiences as of temporal passage, since they must be illusory, should be treated as (at least) analogous to our illusory perceptions of apparent motion.

According to some static theorists, when a series of static images are presented before our brain at some appropriate speed, the apparent (but illusory) dynamicity of reality is produced. This is like appealing to the apparent motion of a cartoon flipbook: the images on each page of a flipbook are static, but when the book is flipped, apparent motion of the imagery is produced — even though the images on each page are of course not moving. In one

influential 2012 paper defending static theory[1], Prosser argues that we experience passage because of a need for economy on the part of the human visual system:

> Imagine first watching a slow sequence of images, slow enough that they are experienced as a series of distinct objects appearing and disappearing, one after the other. There is no persistence, and nothing moves. Imagine now the whole series repeated many times, with each repeated sequence quicker than the last. At some point a threshold is reached at which one's perception switches and one seems instead to perceive a single moving object. At this point there is a clear change in the phenomenology. This, I suggest, is the point at which one's experience represents an enduring object instead of a series of distinct short-lived objects. It is no coincidence that this is also the point as which one starts to experience motion (change of position), as well as other changes in the moving object (if successive still images differ in colour, for example, then one experiences a moving object that changes colour). One's perceptual system is 'lazy' — it no longer 'bothers' to separate the still images as separate identities and instead puts them together as one single moving object, numerically identical throughout.

Without these shortcuts that our perceptual apparatus resorts to, "there would be no experience of dynamic motion or change", according to Prosser.[2]

Gruber and Block (2013) make a similar argument against our experience of motion; for them, any apparent perception of motion is "a frequency-dependent percept" and can be eliminated simply by "choosing the appropriate stimulus frequency". Thus our phenomenal experience of motion is an illusion.

[1]Prosser calls the view that he is defending the B-theory, which you will recall from Chapter 1 is a view inherited from McTaggart. As a reminder, the B-theory is the view that time consists of nothing but the relational properties *being before*, *being simultaneous with*, and *being after*. It is widely accepted that this view is static in nature, since no time will ever change its temporal relations to other times. Certainly Prosser's B-theory is a static theory.

[2]Prosser p.111-112. Note that Prosser is actually invoking Beta Motion here rather than a simple cartoon flipbook — Beta Motion being precisely the same illusion of apparent motion as one derives from the cartoon flipbook, but writ large for the purposes of film or television. I chose to talk about flipbooks instead, for the simple reason that nearly everyone has had the experience of making such things in childhood, while not everyone may know off the top of their heads what Beta Motion is.

And all these sentiments echo L.A. Paul's 2010 "Temporal Experience", wherein she appeals to well-known experiments from cognitive science, involving various dots on a screen which continually blink and thereby create the illusion of a single dot moving across the screen. The upshot is:

> The reductionist can then argue that, if the brain can create the illusion of flow in cases of apparent motion, then it can create the illusion of flow in cases of experiences as of passage. In other words, the reductionist can use the experimental facts involving apparent motion, apparent change, and apparent persistence to argue that, even though all she endorses is the existence of a static universe of a series of stages, this is sufficient for the brain to produce the illusion of motion and flow involved in the experience as of change.[3]

As we can see from the above, Prosser, Gruber and Block, and Paul all assume that the illusion of apparent motion is analogous in the relevant respects to the case of passage. Just like our perception of motion has been shown to be an illusion in situations in which static stimuli are succeeding each other at a certain speed, so too our perception of passage is illusory and due to static stimuli succeeding one another at a certain speed. But, as convenient and tempting as this sort of argument might seem to static theorists, it is way too quick.

First of all, the starting point of the argument is to invoke illusions of motion which our brain is susceptible to only *some* of the time, and only under specific conditions. It is then natural to point out that just because some cases of motion (or flow) are illusory, it doesn't follow that all of them are. This point is nicely made by Deng (2013) in her criticism of Paul:

> To my mind, this... indicates that something has gone wrong, because on the obvious reading, it merely says that there are illusory perceptions of motion. Of course there is no phenomenal difference between our experience of instantaneous objects spatiotemporally spaced such that they seem to us like a single moving

[3]Paul p. 353.

> object, and our experience of moving objects. Contrary to suggestion, that fact does not constitute any sense in which ordinary perception of motion and change is illusory.[4]

In fact, one could push Deng's point even further and suggest that the cases of illusion of motion do not serve the static theorist's purposes well at all due to the implicit background reliance on the cases of genuine motion. That is, the backdrop of the argument is that *sometimes* there is genuine motion, that we have epistemic access to such genuine motion, and that sometimes situations which are not cases of genuine motion may wrongly appear to be such. If we were to make an analogy from this filled-out picture in the case of motion, to the case of passage, our static theorists would not get what they are aiming for at all. The analogy would only get us that there are some cases of illusion of passage against the backdrop of genuine passage, which we have veridical perceptions of most of the time.

Yet for even this more modest version of the argument to work, it must be shown that what is being compared is analogous in relevant respects. Arguments from analogy are notoriously weak and difficult to assess in a rigorous way, but one minimal requirement for the analogy to work is that the two cases compared be similar in relevant respects. Is the case of passage relevantly similar to the case of motion?

None of the aforementioned authors explicitly address why this analogy from motion to passage is thought to work, but here's my attempt at an explanation: one can think of motion as (at least) a special case, or species, of change. That is, something's being in motion is sufficient for its having changed, for in order for it to be in motion, it has to have changed its spatial location.[5] Now, something's having changed is sufficient for time to have passed (in a weak sense of passage (succession-type passage) that is amenable even to static theorists). This is because, in order to have changed, an object must have a property at t_1, and a different property at t_2. (Note that I am not endorsing at-at change here, but only trying to

[4]Deng, p.376

[5]It might be the case that something's being in motion is actually also necessary (not just sufficient) for change, as changing colors, temperatures, or even changing your mind all require molecular movement to occur. But I need not push that stronger point here.

understand the thinking of these authors.) So change is, at least, a species or special case of temporal passage.[6] Now, if motion is a species of change, and change is a species of temporal passage, then motion is a species of temporal passage. Ergo, illusions of motion are illusions of passage, or at least a species of them. To put it another way: for static theorists, both "passage" and motion are nothing but at-at change. That is why passage and motion can get the same treatment.

But this still leaves us with the rather underwhelming result that we can show that some cases of passage are illusory — not all. This will hardly do for a global error theory of passage, and it's hard to see how that could possibly be the motivation of such talented philosophers as the static theorists we've mentioned here. So how can we more charitably interpret the static theorists' arguments?

One suggestion is that the static theorists want to follow Descartes's method of radical doubt in his Meditation I, and they might be thinking that doubting our perceptions in some cases of motion (that is, in cases of apparent motion) should be sufficient to put into doubt all of our perceptions of motion. If a small subset of cases can be doubted, then all of them can be doubted, and therefore it might be the case that there is no such thing as genuine motion at all. All our perceptions of motion might be merely illusory. And similarly all our perceptions of passage might be illusory. And "might be" is good enough, if all you need to do is provide a possible explanation of our experiences as of passage. After all, the motivation behind the dynamic theorist's demand for an error theory is the idea that the static theory can't account for any such experiences. A single (reasonably plausible) explanation refutes that charge. And here we have a possible explanation: phenomenal passage is illusory in the same way that cases of apparent motion are illusory.[7]

However, I think even this charitable version of the argument fails. That is because I

[6] As before, it might be the case that something's changing is also necessary for time's passing, but those who hold substantivalist views might reject this claim, on grounds that spatiotemporal locations are not dependent on objects. At any rate, I needn't push this either right now.

[7] There might not be enough ground to assign such a position to Prosser and Paul. The move from some illusory perceptions to all illusory perceptions is never explicitly made or appealed to in their arguments. I am simply trying to provide a charitable reading of their work that gives us a way of understanding them as responding to the demand for an error theory.

think there is good reason for thinking that it is *impossible* that all cases of experiences of passage are illusory. The problem with appealing to illusions of apparent motion to explain our phenomenal experience is – to use the flipbook analogy again – that a flipbook has to be *flipped*, that is, put into genuine motion, in order for the illusion of apparent motion to be produced. All illusions of motion require genuine motion in order to get off the ground.[8] Similarly, as I will show, all experiences as of passage will require genuine passage as an enabling condition. Static theorists who attempt to explain away our phenomenal experience in this way thus end up presupposing a dynamic reality in their quest to produce the result that reality is actually static. This is what I will call the "Flipbook Objection" to the static-theoretic illusion account of phenomenal passage.

4.2.2 The Flipbook Objection

Consider the experience of watching water leaking slowly from a faucet, drip by drip: the droplet forms, becomes fat and heavy, and falls into the basin as you watch. Another droplet forms, and the process repeats. As the droplet forms and falls, it seems to do so fluidly, successively, without breaks or stops or interruptions. But if the static theorist is correct, your experience should be somewhat surprising. For if the static theorist is correct, then the droplet's changing states are correctly (roughly) described as follows: droplet-on-the-faucet at t_1, droplet-slightly-bigger at t_2, droplet-begins-to-fall at t_3, droplet-halfway-fallen at t_4, etc. One can imagine making a cartoon flipbook of such an event — each page containing an instantaneous, static image of the droplet. Laid side-by-side, the pages do not give any illusion of motion or succession, but only show the droplet, with its varying properties, at various stages in the event. Only when the pages are flipped does the image become dynamic, successive, flowing. Yet all of our everyday experiences are like the flipping booklet: they contain this experience of flowing succession, of the apparent dynamic passage of time. So the

[8] I cite no examples here because this is intended to be a claim based on principle, to be explained further in the chapter, rather than an empirical claim. But in case anyone is thinking of cases of static images that appear to be in motion simply because of their high contrast patterns – cases of "optical flow" – these require motion in both the eye and the brain (i.e., of neuronal firing) in order to be generated. It is worth noting that ultimately any experience of succession or motion will require movement (of a sort) in the brain.

question becomes: is reality only comprised of "static" objects-at-times, or is there anything more to motion "over and above" this picture?

Dynamic theorists – myself included – answer that there must be something more to motion and change (and therefore to passage) than the at-at view, the mere "aligning" of static objects-at-times. As Peter Geach (1969) puts it:

> Even if a man's impressions as to which realities are past, present, and future are illusory, the fact that he has in that case different and uncombinable illusions shows that at least his illusions really are successive — that they are not all present together, but now one illusion is present and now another.[9]

Note that Geach's use of the word "successive" may be misleading, since there is a perfectly static-theoretic way of understanding succession: taking the case of the booklet pages laid out side-by-side again, it's true that one page is located "before" another — in space. But Geach here follows up by emphasizing that what he means by "successive" is that they are not all present together — that they are not all located together in time. And certainly a set of pages can be lined up in spatial succession while maintaining temporal simultaneity — the pages can all be laid out on the table, in an order, at the same time.[10,11]

But static theorists argue that there isn't anything more to what we observed in the water droplet's motion than the droplets-at-times. For them, the pages lined up in an ordering upon a table seems sufficient to explain the change in the appearance of the droplets on the pages, and hence to explain the "motion" of the droplets. They then need to address the following further question: if the temporal passage we (seem to) perceive is only illusory, then what is responsible for that illusion?

[9]Geach, P.T. (1969). God and the soul. New York: Schocken Books, p. 92.

[10]Moreover, the pages can be lined up in spatial "simultaneity" (located in the same spatial location) just so long as they are not temporally simultaneous: more than one object cannot share the same spatial location at the same time.

[11]Talk of "simultaneity" here might be worrying people who recall that the STR shows that simultaneity is relative, that is, that there is no relation of absolute simultaneity; simultaneity is relative to the choice of reference frame. So, properly, the pages *can't* be laid out on the table in an absolutely temporally simultaneous way. But no claim is being made about absolute temporal simultaneity; and anyway, locally, the pages on the table are very close together, so they will be apparently simultaneous to any human observer. That is all that is needed to make the point here.

As discussed earlier, some static theorists attempt to give an answer to that question by appealing to what we know about other illusions of apparent motion: they all involve the speed of what we perceive — that is, the frequency of the stimulus that produces the phenomenal response in question. Flipped at the right speed, the flipbook produces the illusion of motion; but the images on each page contain no motion in and of themselves.

But that drags in a still-worse conundrum: for then it remains to be explained what is meant by the 'speed' or 'frequency' of the stimuli, without reference to genuine motion or to time's passage (since the lack of these is what the static theorist is trying to defend).

Are there any plausible meanings of 'speed' or 'frequency' in this context which make no such objectionable reference? Surely these words don't mean, for instance, to refer to how close the stimuli are to each other in physical space. Lining up the pages of a flipbook very close to each other on a surface – say, a table – does not produce any illusion of motion.

Instead one *prima facie* plausible interpretation of 'speed' or 'frequency' might be "how close the objects (or events) are to each other in time".

But what could that mean? Saying that two objects are very close to each other in time doesn't seem to mean, for instance, that there is some very tiny change from t_1 to t_2. That is, it doesn't seem to be that such static theorists are saying that the illusion of apparent motion is due to an extraordinary number of small changes in the objects. But suppose they did mean that. That is, the "closeness" of the stimuli might just refer to the size of the intervals — the size of the temporal regions which the stimuli "inhabit". Take our water droplet case: perhaps we mean to say that we perceive apparent dynamicity in the falling of the water droplet because each of the changes in the water droplet takes less than some perceptible fraction of a second to occur. Since we cannot perceive the intervals of the smallest changes, we perceive only a continuous larger change — the falling of the droplet. But I worry that this is no use to our proposed explanation: fattening a flipbook version of our droplet case, with many more drawings of the droplet of water in ever-more-fine-grained in-between states, does not, by itself, produce the illusion of motion — until the flipbook is flipped. If our experiences of motion are illusory – no more real than apparent motion – then

we need something more in our explanation than an appeal to small changes.

As the above discussion illustrates, the reference to "frequency" and "speed" is quite problematic, and does not give the static theorists an adequate replacement for passage. The flipping of the flipbook – the putting of the objects into genuine motion that gives rise to the illusion of motion – is the real explanandum here, and it's no help at all to say that the flipping itself, as a case of motion, is another sort of illusion: then we will need an explanation of the flipping without reference to "speed" – another kind of "flipping" – to get the illusion of flipping off the ground, and so on ad infinitum.

If I'm right about this, then static theorists' appeal to illusion is simply insufficient to explain away our phenomenal experience of the passage of time, because there will be no way to generate an illusion without letting temporal passage in through the back door. So, if we do have experiences of passage, then either some of them are veridical, and we are, in those cases, experiencing genuine passage, or they are all illusory and we are not experiencing passage directly, even though there is genuine passage in the universe (that is, the "flipping", even if the flipbook produces an illusion of motion, is still required). But, in either case, to be able to have an illusory experience of passage of time, there still needs to be the genuine passage of time to enable it.

4.2.3 Projection accounts of temporal passage

Craig Callender (2017, 2019) has suggested that accounts that attempt to explain time's passage with reference to dual cognitive processing systems that represent both the present and the existence of all times (past, present, and future) miss something important: they underwrite a view of the world according to which there is tension between believing that only the present exists and believing that all times exist equally, but they don't underwrite the *flow* aspect of passage. As he puts it (2019): "The temporal monotonic updating is updating something...to make sense of [these beliefs we have about what exists], something must endure (or appear to endure) through time."

He suggests that what must endure is our self: that we construct selves on our own world-

lines, giving the appearance that something endures when in fact nothing does. But it is this unchanging backdrop that appears to endure through time and thus gives us the sense of all other things changing, i.e., of time's passage (2017, p.247, 250-251, 253):

> The extra ingredient needed to get flow, I submit, is *the self*...
>
> You take yourself to be one and the same entity throughout your life. Yet we face all these changes. These changes must be changes with respect to something. The suggestion is that the self understands time to be changing in some way...Thanks largely to autobiographical memories, I construct a narrative that, accurate or not, is what I associate with my self, the hypothetical entity that survives through time...
>
> So if you grant me that endurantism gives one a sense that the ego is moving through time, then I claim that is tantamount to regarding time as dynamic.

This type of error theory for the illusion of passage is known as a projection account: we project our enduring selves onto the world, and against these unchanging selves we experience other changes, giving the illusion of dynamicity. But projection accounts quickly fall victim to the same sorts of problems as other illusion-based accounts. That is because they involve projection in order to work, which must be a dynamic process: if the apparently-enduring self is just another detail on a static page of a flipbook, then it's unclear how this could make the rest of the details on a given page appear to be in motion at any given time (page). The apparent motion only comes about from "flipping" the book. If the apparently-enduring self is instead meant to be the backdrop – that is, if the apparently-enduring self is best represented by either the page itself upon which details are drawn and the world is understood, or perhaps even as the viewer of the pages, outside of the book – then still we need some kind of 'flipping' in order to see motion in the rest of the details. So there is still the importing of dynamicity through the backdoor in order to explain how dynamicity is an illusion. (Note how Callendar invokes 'updat*ing*' in his description of what our cognitive processes do to represent times to us.)

Additionally, there is the broader problematic assumption in Callender's argument that something must (appear to) endure in order to make sense of change. (This is similar to the assumption of Taylor that there must be a hypertime upon which background times are able to change.) These difficulties can be traced to Lewis' problematic setup of the problem of identity over time, which has completely framed the discussion since it was first published in 1986 as the problem of temporary intrinsics. I will discuss this more in Chapter 5, since it is not necessary for the present discussion; all I meant to do here was show that these kinds of projection accounts fail as error theories for our experiences as of passage in the same way that other illusion-based accounts do.

4.2.4 An argument for taking the phenomenology of passage seriously

If the Flipbook Objection – the point I have pressed here that all illusions of passage require genuine physical passage in order to be illusions – is correct, then our phenomenal experiences actually tell us something quite profound about what reality must be like. For consider: what is the "flipping" of the flipbook example supposed to represent? It is not the mere movement of the background of the drawings; rather, each page represents a moment of time itself, in which the event – the object-at-that-time – is "happening". So the flipping represents time's passage in a very real, dynamic-theoretic sense: the succession of times as they become present to our experience. (One cannot see the pages ahead, or the ones already "flipped", while the flipping is occurring.)

To be clear: I am doubtful that one can coherently speak of a happening at an instant. But, I am also doubtful that there are discrete objects located at discrete times - the pages of the flipbook - which seems to involve, at a minimum, a commitment to at-at change, and so to substantivalism. My point here is not to assert that the universe is like a flipbook which really is "flipping". I think it is not like that. My point here is that, if we take on the assumptions of static theorists, which model the universe as if it were a flipbook, then we have to ask what the flipping represents, because we cannot avoid the flipping aspect if we admit that we have experiences as of passage.

If the analogy is apt, then the flipping - the passage of time - must genuinely take place in some way in order to produce any illusion at all. And I can think of two ways for it to take place: either as a physical phenomenon – in which case the static theory is incorrect – or as a mental (purely phenomenal) phenomenon.[12]

But what would it look like to save the static theory by taking that second option?

Suppose we say that physical reality is actually static and the illusion of motion is just a strange quality of phenomenal experience. We perceive passage even where there is none in physical reality, because temporal passage does really exist — but it only exists phenomenally (mind-dependently). That is, suppose physical reality is as the static theory says, but phenomenal time is dynamic-theoretic time. Then what we're saying is that the phenomenal has a character that the physical does not. In short, we are widening the gap between the phenomenal and the physical by positing a non-reducible feature belonging solely to the phenomenal.

Why non-reducible? First, we experience phenomenal passage or "genuine motion" literally all the time; arguably there is never a time when our experiences are not "as of" passage. Consequently it would be ridiculous to suggest that any particular brain state was identifiable with the phenomenon of passage. One would have to say instead that all conscious brain states are identical to, or give rise to, the phenomenal experience "as of" passage, or, in short, that consciousness itself – no matter where or how it occurs – is fundamentally "dynamically-timed". This is a kind of multiple realizability problem that reductive physicalism does not seem equipped to handle: if any conscious experience, of any conscious being whatsoever, contains the experience of passage, no matter what physical states the conscious being is in, it is hard to imagine a reduction of that experience done either in explanatory or Nagelian terms.[13] The static theorist taking this road is thus left with the option of embrac-

[12]To be fair, it could be both physical and mental – as in a kind of panpsychism – or neither, if our usual ontological categories, which divide the world up into the physical and the mental, are radically wrong. I can say nothing about the latter possibility. As for the former, I think the passage of time being even partly physical in nature would make being a static theorist impossible.

[13]I.e., with "bridge laws" posited as "go-betweens" for individual physical phenomena and the resulting non-micro-physical phenomena.

ing either dualism, where the experience of passage is just part of how minds work, but this experiencing has nothing to do with the physical world, or else non-reductive physicalism, according to which the experience of passage is an intrinsic feature of phenomenal experience that cannot be reduced to the physical, but still somehow supervenes on the physical. Thus, on this way out, to have a conscious state is, necessarily, for there to be an experience of passage for the being having the conscious state. And while dualism is likely not amenable to many philosophers who are static theorists because of they believe the physical sciences are our best guide to reality and that these sciences require static theory, the alternative – non-reductive physicalism – is perhaps not so bad a consequence. Many philosophers today are non-reductive physicalists as a result of worries about multiple realizability problems, and are content to have all sorts of unusual phenomenal properties arising from a world that is still nevertheless physical.

If one is a dualist, then it would be odd to appeal to results from cognitive science about how illusions are generated in the brain in order to try to explain our "illusion" of temporal passage; one should just say that passage isn't illusory, it's purely a (physically inexplicable) property of minds. Of course, one would need a further argument for temporal passage being a purely mental phenomenon, perhaps some sort of inference to the best explanation — that is, if we accept substantivalism, then dualism is the best explanation for our experiences of passage. (And I'll grant that it might be, if one assumes substantivalism. I just don't think substantivalism holds.) And the dualist will still have to explain how it is that our experiences of passage always align with – indeed, seem to be necessitated by – the physical facts, and will be left in any case with mysterious mental properties that cannot be explained.

On the other hand, if one is a non-reductive physicalist, one will have to explain how it is that one's position *differs* from the sort of dualist who says that our experiences are necessitated by the physical facts. What makes one's view still physicalist, and what is the relationship between the physical facts about time and the mental phenomenon of the experience of temporal passage?

In fact, I think that any physicalist, reductive or not, is in trouble here. For, no physicalist

view can explain how it is that the mind gives rise to the illusion of temporal passage, because the mind itself is "on the page" which is to be explained. That is to say, the mind itself is part of the physical universe on any physicalist view.[14] So, if a given page of the flipbook represents the universe at some time t, all of the minds in the universe must be represented on that page. And how could static pages – static slices of mental experience, if we can even make sense of a static notion of experience – combine to make up the illusion of a dynamic experience of passage? The Flipbook Objection will still come into play: putting a bunch of static images near each other does not result in any illusion of dynamicity. What would serve to do the "flipping" for the mind, if the mind itself is no more than a succession of static stages, and so cannot be invoked to explain the "flipping" that generates the illusion?

So the options (for the static theorist) in responding to the Flipbook Objection seem to be:

1. Embrace dualism of a strong sort, according to which the experience of passage is just a mysterious property of minds that has nothing to do with the physical world

2. Try to take some sort of physicalist stance, but hold that the experience of passage is a mystery, a phenomenon that is (even in principle) unexplainable, despite emerging from the physical world in some way

3. Give up illusion accounts of the experience of passage

4. Give up the static theory and accept that the universe is dynamic, that is, that passage is a real feature of the physical universe

I think that one should only try to take options (1) or (2) if one is committed to substantivalism. This is because the only reason to maintain an illusion-based account of passage, in the face of the objections I've pressed here, is if one is strongly committed to at-at change, which illusion-based accounts are based on. And at-at change is incompatible with relationalism, as I argued in Chapter 3. But there are strong independent reasons for rejecting

[14]That is, the minds of the observers within the physical universe.

substantivalism. However, even if one disagrees that at-at change is incompatible with relationalism, I still think that one should only hold the kind of mysterianism of the sort that would be required for (2) if one has very strong independent reasons for holding a view that requires such a mysterianism. So, if one still wants to keep a static-theoretic view, it makes the most sense to either abandon physicalism and take option (1), or to take option (3) and abandon illusion accounts of the experience of passage.

As I've mentioned, most static theorists are static theorists because they are committed to a strong kind of methodological naturalism (and thus think that the best interpretation of the physics of spacetime requires us to reject dynamic theory). These people are not likely to be interested in option (1). So, in what follows, I will discuss static-theoretic accounts of the experience of passage that try to take option (3).

4.3 On whether or not we could (veridically) experience passage

The aim of the previous section was to argue that if we have experiences as of the passage of time, then time must actually be passing. But some static theorists have disputed the very possibility of having veridical experiences of temporal passage, and then further claim that this impossibility means our experiences as of passage cannot be used to argue for its existence.

To take an example: Simon Prosser (2007) has argued that the nature of our experience is determined once the B-series (static) facts are determined, and then the passage of time has no work to do in shaping our experience; hence it cannot be veridically experienced. (To be clear, he does not deny that we have an experience as of time's passage; merely that this experience could not possibly be veridical.) Moreover, he argues, one cannot argue for the existence of passage unless it is experienced veridically, because we have no grasp on what passage is supposed to be except through our experiences; if they are not veridical then they tell us nothing about the real world. So, he concludes, passage does not exist.

To elaborate a bit more, his central argument runs as follows: First, Prosser argues that

temporal passage, if it existed, would be epiphenomenal to the physical state of the world in the sense that it would neither cause nor influence physical events. This claim is made on the grounds that he thinks physical events can all be accounted for with the laws of physics, which make no reference to temporal passage. A physicist, Prosser thinks, can describe the world, and all its previous and subsequent states, in static-theoretic terms. As he puts it, "Given an arrangement of matter at one time, the nomologically possible arrangements of matter at earlier and later times are constrained only by the laws of physics and not in any way by real temporal passage." (p.83)

Next, Prosser argues that if conscious states supervene on physical states, and temporal passage is epiphenomenal with respect to all physical states, then temporal passage is epiphenomenal with respect to experience. For, after all, temporal passage can't modify brain states if it is epiphenomenal to the physical. So, he argues, we cannot possibly experience the (veridical) passage of time.

Prosser then argues that our grasp of what is meant by 'temporal passage' derives from the nature of our experiences as of passage. So, whatever we think about temporal passage, we are thinking it only of whatever phenomenon produces our experience as of passage. We do not have independent reason to believe there is temporal passage in nature outside of our experiences. And if physical temporal passage is not what produces that experience – if the experience is not veridical – then whatever our phrase 'temporal passage' picks out, it is not physical temporal passage. Consequently, we have no reason to believe in physical temporal passage. So, we should not believe it exists.

As an analogy, he offers color phenomena. He says that our experiences of color are the reason we believe colors exist, distinguish different colors, and give them names. But if we found out that colors were just due to arbitrary brain processes that had nothing to do with the physical world – if the experience of redness was more like a dizzy spell or a headache than like a visual perception of an external feature of the world – no one would argue that colors still existed mind-independently. Whatever mind-independent features of reality there might be in such a world – even if there were a mind-independent redness which we just

did not experience – our grasp on colors derives from our experience, and none of those mind-independent features would deserve to be called 'redness'.

I have a number of concerns with Prosser's arguments, but I will try to keep them brief.

First, in assuming that the laws of physics do not make reference to temporal passage, I think Prosser is assuming that temporal passage can only be identified with A-theoretic properties: being present, being past, being future. He refers to "A-series properties and the associated temporal passage", but he gives no definition of what temporal passage is supposed to be, apart from those properties. It is true that the laws of physics are not generally formulated in A-theoretic terms. But if we examine passage, as we did in Chapter 2, we see that our experience as of passage is really an experience as of change. It would be very odd indeed to claim that the laws of physics make no reference to, or do not involve, change. Even static theorists have a notion of change, of times succeeding each other. And so one cannot say that the laws of physics have no need of passage and therefore conclude that passage is epiphenomenal because it has no work to do in determining the state of the universe; *change* clearly does have work to do in determining the state of the universe, on either a dynamic or static theoretic account.

Second, I also take issue with Prosser's assumption that our concept of the passage of time can only be derived through veridical experience. We have seen, in Chapter 2, several characterizations of passage that do not appeal to experience at all. So, it's not the case that we cannot understand the notion of passage as divorced from experience. Rather, whether necessarily or contingently, genuine passage is an enabling condition of all of our experiences. It is not relevantly like our experience of color; we can have experiences that are not red, but we cannot have experiences at all without change — in the world, including in our brains.

It is true that we infer the existence of temporal passage through our experiences as of passage, but that isn't where the buck stops, so to speak. We take our experiences as of passage and we subject them to critical thought, decide whether or not such a notion is coherent given the other information we have about the world, and from there develop accounts of what passage must be like if it does exist. This is no different than — well,

almost any concept we have.

Prosser has a response to this line of thinking. He says that, if one tries to argue that temporal passage is what enables experience, then every experience should count as an experience of time's passage, which he thinks is absurd. For instance, the experience of the redness of a ripe tomato would count as an experience of time, but, he says, temporal experience has a distinct phenomenology, which we should be accounting for with a distinct phenomenon.

I think a small but crucial mistake is being made here. I do not think it's the case that every experience should count as an experience of time's passage. I think it's the case that every experience *involves* the experience of time's passage, in the sense that one *could* attend to time's passing in any experience. Compare one's sense of being alive: even though it has a distinct phenomenology, it is involved in every experience we have; this, however, does not mean that every experience is the experience of being alive.

So it's not the case that we cannot possibly have veridical experiences of temporal passage because any such experience would necessarily be epiphenomenal. But if it were the case, it still would not follow that we could not infer the existence of a genuine physical passage from illusory experiences. (See the points from the previous section.) The existence of our experiences – any experience – points to the existence of temporal passage.

4.4 On whether the phenomenology should bear on the metaphysics

All of the previous section's argument about whether or not we can*can* experience passage veridically seems to involve the presupposition that if we could experience passage veridically, then that fact would matter for our views about how temporal passage really is. But some have argued that our phenomenology shouldn't be brought to bear on our metaphysics at all. Jiri Benovsky is a notable proponent of the view that our phenomenology can't tell us anything useful about the way the world is with respect to time.

Benovsky (2016) has argued that our phenomenal experiences of dynamicity cannot be used as evidence either for or against any particular metaphysics of time, on the grounds that dynamic-theoretic intuitions about passage are not deep philosophical insights; they're no more than expressions of how we perceive the world, which is contingent upon how our perceptual system is built. Given what we know about illusions of apparent motion, our phenomenal experiences of reality would be the same regardless of whether the dynamic theory or the static theory turned out to be correct. That is, our phenomenal experiences of motion are known to be limited to certain durations – too fast and we don't perceive it; too slow and we don't perceive it – and this fact, Benovsky says, is consistent with either the dynamic or the static theory holding: the dynamic theory could be correct, and yet, because of cognitive limitations, our experiences of motion are illusory; the static theory could be correct, and then our experiences of motion would also be illusory (since genuine physical passage would not actually exist, which is assumed as a precondition of genuine motion).

I have already argued that we could not have experiences without the passage of time, and that illusions themselves imply genuine passage. But there is yet more to say to Benovsky, who thinks that the faulty nature of our intuitions means that they are unreliable sources for metaphysical theorizing.

First, I think it's unclear that anyone thinks of phenomenal passage as either an "intuition" or a "deep philosophical insight", whatever those terms are supposed to mean. There are experiences as of passage which function as points of entry for dynamic theorists, who accept that we can learn about the world from our phenomenology. Benovsky suggests to the contrary that we can't learn about the metaphysical nature of things in this way because our phenomenology is notoriously unreliable and can be influenced by things like culture, modes of presentation of stimuli, etc. But that unreliable phenomenology is the go-between for us and all our scientific knowledge: nearly everything we learn about the contingent world is learned through experience.

If Benovsky is not trying to throw out all knowledge of the contingent world, then perhaps he is trying to make a sharp divide between what experience can tell us (only about

contingent matters) and what truths of metaphysics are (necessary truths about what must be). But I contend that both scientific theorizing and metaphysical theorizing make use of empirical investigation (done through the lens of our phenomenology!) and a priori reasoning. Both make use of intuitions, which we might loosely define as prereflective assumptions or beliefs about how things are. Sure, they are sometimes unreliable. But their errors do not go unaccounted for: scientific practice is built around repetition, to try to weed out errors that result from particular perspectives and biases. Metaphysicists, too, examine their phenomenology and their intuitions, question them, build theories based on them, see how well they account for the data, and attempt to account for their intuitions' mistakes when due theorizing shows them to be misguided. (And were this not the case in actual practice, the static theory itself would have never gotten off the ground. Certainly the world does not *appear* to be static.)

Now, Benovsky might complain to me, "You've only said what we do in actual practice. But I am making a normative assertion — arguing that we ought not involve our intuitions in our metaphysical theorizing, because they are unreliable." In response to this, I can only ask for the missing step in the argument that takes us from "intuitions are sometimes wrong" to "intuitions are always wrong". Just because we might be theorizing about how something must be, does not mean that we can only successfully arrive at such a theory via a method that never makes mistakes. And, indeed, we do not arrive at any theory, in physics or metaphysics, via a method that never makes mistakes. Humans have cognitive limits: our powers of reasoning fail us, our perceptions are skewed in a wide variety of circumstances, our memories fail. Nevertheless, we seem to be remarkably effective in investigating the world.

4.5 Conclusion

Earlier, in the section on illusion-based error theories for our experiences as of passage, I argued that the static theorist ought to do one of four things: (1) embrace a strong version of dualism that makes temporal passage a property only of minds, with no relation to the

physical world; (2) try to take a (non-reductive) physicalist stance coupled with a kind of mysterianism about the experience of passage; (3) give up the illusion accounts of the experience of passage, or (4) give up static theory and accept that passage is a genuine feature of the physical universe.

I think that I have shown in this chapter that option (3) is a must for anyone. Illusion accounts always import dynamicity in their attempts to explain the static-theoretic world. But I hope I have also shown that attempts to evade the demand for an error theory, in the form of (various versions of) denying that our phenomenology bears on the metaphysics, also fail. This leaves options (1) and (2) on the table for those who wish to maintain the static theory.

This is not a dissertation on the philosophy of mind. Nevertheless, I have tried to give some reason for thinking that (1) and (2) are weaker options than option (4), and that (2) in particular is very weak, because the cost of keeping one's physicalism just in the name of keeping one's static-theoretic commitments, when doing so undermines the very possibility of even loose physical explanations for certain phenomena, seems very steep. (Indeed, such a physicalism threatens to collapse into dualism very quickly, I fear.)

It is, at the very least, an initially surprising consequence that denying that temporal passage is a real feature of the physical universe leads one almost inevitably to dualism. I do not think most static theorists are likely to rush to embrace dualism, at any rate. And I am not going to argue here against dualism. But that is the cost of separating our phenomenology from the natural world.

And our phenomenology must be taken seriously.

Chapter 5

CONCLUDING REMARKS

5.1 Summary

What I hoped to persuade you of, in this dissertation, was that *time passes*. This is a view which probably most people outside of physics and philosophy already hold. (Indeed, I have received some strange looks in trying to explain to non-philosopher friends what it is exactly that I've spent the last decade working on.) But within philosophy, it requires some effort to establish; it is not the dominant view, and, by my lights, the literature on the subject is hopelessly confused in a number of places. I wanted to untangle some of the existing confusion.

I began this process of untangling by giving a lay-out of the land in the metaphysics of time — that is, by giving an overview of the four dominant positions in debates about temporal ontology, where the most pressing question about time has generally be taken to be a question about whether past and future times exist in the same sense that present times exist. In carefully characterizing each of the four views – presentism, eternalism, growing block theory, and the moving spotlight view – it became apparent that each view endorses, not just an ontological thesis about what exists, but also a thesis about whether or not the world is static or dynamic — that is, whether or not *time passes*.

After examining the ontological theses in more detail, I argued that these theses could not generate a substantive metaphysical dispute, for there is apparently no way of formulating them that does not make the debate into a trivial one about the meaning of 'exists', unless one takes existence as a genuine property. Instead, I claimed, the best way to characterize the debate is in terms of whether not temporal passage is a real feature of the physical world.

I then turned, in Chapter 2, to asking what temporal passage is supposed to *be*. I

examined four extant types of account of passage, and gave some criticism of each. I pointed out that the main reason anyone believes in passage is because of our experiences as of temporal passage, which are really experiences as of change. I showed that the extant views of passage which we examined appear to rely on the standard at-at view of change. I then argued that at-at change is the wrong analysis of change, because it assumes incorrectly that both objects and times exist as fundamental, definite entities. I argued for a different view of change, which I call the process view of change, which takes process as ontologically prior to properties, and therefore to objects, and therefore to times. Because processes (changes) are inherently temporal, in that they are how we come to define time itself, and because temporal passage is to be identified with change, temporal passage is to be identified with process, and should be considered a fundamental, intrinsic feature of physical reality.

The process view of change, however, requires relationalism to work. So in Chapter 3, I examined substantivalism and relationalism in detail. I gave a history of the debate, tried to find plausible ways to characterize substantivalism and relationalism, and then provided five of the most pressing arguments for or against substantivalism. Ultimately, I argued that relationalism is the correct view, independent of any considerations about temporal passage. This is because the main arguments for substantivalism are weak and require us to add both unnecessary and unobservable entities into our ontology, while simultaneously undermining the determining power of our physical theories. Relationalism carries with it no such extra burden.

Arguably, most, if not all, of the other views of passage which we discussed in Chapter 2 require substantivalism to work, either because they are explicitly committed to it at the outset, or because they have the at-at view of change, which is incompatible with relationalism. Therefore, if relationalism is true, then none of those views of passage are correct; so, if time passes, we should think that it does so in terms of process.

But we still needed to establish why someone should believe that time passes. I mentioned before that the main reason people believe in time's passage is because of their experiences as of passage. But common sense does not always tell us the full story. Many things are

not the way they appear. The Earth appears to be (relatively) flat, after all. So why should we take seriously the appearance of temporal passage? In Chapter 4, I argued that any experience as of passage requires genuine physical passage as an enabling condition. This is because there is no way to create the illusion of passage without reference to genuine physical passage; a series of static events cannot by themselves generate an illusion of dynamism. I used the analogy of a cartoon flipbook: if the universe is like the static theorist says it is, then the static events which comprise each position in spacetime are like the pages of a flipbook, which cannot generate an illusion of motion until the pages are flipped — and we cannot explain what does the "flipping" in the case of the physical universe without either importing genuine physical passage in through the backdoor, or by separating the physical universe from phenomenal passage. This means that the only way to save the static theory is to embrace dualism.

So, if one is not a dualist *and* a substantivalist, one should accept that time really passes — that temporal passage is a feature of the physical universe.

5.2 Loose ends and open questions

What I say in the sections that follow should be taken as tentative explorations of the consequences of my view, rather than outright assertions. I *think* that what I say here is roughly correct - or at least, I think so presently. But I am not quite sure enough of these things to make extended cases for them. Still, there are a variety of questions and topics left open by my dissertation, some of which I thought it reasonable to try to give a sense of my current thinking about them.

5.2.1 Returning to the Temporal Ontology room

As I mentioned in Chapter 1 of this work, it certainly seems intelligible to ask whether or not Socrates exists. What happens when we try to re-evaluate temporal ontology questions in the light of the process view of passage which I have advocated for?

We can start by trying to understand the question "Does Socrates exist?" as "Is there a process (or set of processes) which we would call Socrates 'out there' somewhere?" And the answers seems to be that, if we model the world one way – in an eternalist way – there is. If we model the world another way – in a presentist way – there is not. But in reality, outside of the model, there is no time for Socrates to be at, and there is no discrete entity 'Socrates'. Even at the time in which Socrates lived, there were just a bunch of processes, some of which one decides to designate 'Socrates', and one points to perceived differences in Socrates – arbitrary parts of those processes – in order to delineate the times in which he 'exists'. So the question doesn't even make sense on a process model of the world. "Is there an O at any t?" presupposes Os and ts. I might as well ask, "Is there a Santa Claus in Valhalla?" One answer is no: not on the standard fictions about Santa Claus and Valhalla. One answer is yes: I can imagine Santa Claus anywhere I damn well please. But the real answer is that there isn't a Santa Claus nor a Valhalla, at least not in the physical world.

The relativity of simultaneity seems to imply that there is no privileged present and therefore, many have concluded, presentism is false and eternalism is true; I think it is better to say that it implies that there is no privileged model of the world. That is, it makes an epistemological claim (about what we have reason to model) rather than a metaphysical one (about what is "out there", or what is physically exemplified).

To put it yet another way: questions of *what* exists *when* are hopelessly confused because they assume one can separate a *what* from a *when*. But the universe is not like a container or a flipbook. Like death, digestion, and other processes, temporal passage doesn't take place at a time. Nothing takes place at a time, for there are no times. Times are mental abstractions, our attempts to describe the world at an "instant" because this makes things comprehensible, mentally manipulable. But of course the world is much messier than that. Things evolve – insofar as there are things! – and so a given moment of, e.g., 1956 doesn't exist "out there somewhere" as static theorists would have us believe, because the things in that moment have changed: that is, time has passed. The universe is not a series of static pages laid next to each other, as the static theorist would have it; nor it is a single page constantly replacing

itself with a new one, or being erased and made anew, as presentists would have it. There are just the things people try to understand as drawings on a page (that is, at a time) — each evolving, changing, irrevocably so, at their own rate; and enough overlap of rate that it seems to us to be a global phenomenon, and so we can imagine or project simultaneity classes (pages, nows) where really that is nonsense.

This means that the presentist is right about Socrates not being 'out there somewhere', in the sense that there is nowhere for him to be; but the eternalist is right that all times are equally ontologically on a par, in the sense that all times are abstractions from objects, and all times can be modeled equally well.

So, we shouldn't be presentists, eternalists, growing blockists, or moving spotlight theorists. These models do not match the actual world well enough to be endorsed because they presuppose definite objects and concrete times. We should reject questions like "Do past things exist?" as nonsense, at least when we are applying the kind of 'strict scrutiny' that I have argued is required for doing the metaphysics of time.

People have assumed the deadlock in the temporal ontology debate came about because presentism accords with our phenomenology, and eternalism accords with the physics. I initially thought this too — that the deadlock was because of a clash about which sorts of evidence should matter more to our theorizing. Accordingly, some of the more clever of the proponents of each view have tried to show that their view doesn't really involve a denial of the "good parts" of the opposing view: that presentism is compatible with STR (Markosian) or that eternalism doesn't really conflict with our phenomenology (Benovsky, Prosser). But this isn't actually the real issue driving the deadlock. The real issue is in the framing of the problem: presentism needs substantivalism to function (because it cannot make sense of at-at change otherwise, which it needs to define the moving present), but that is incompatible with the dynamic thesis that it explicitly embraces; eternalism needs dynamism to function (because it cannot make sense of the dynamic nature of our experience otherwise), but that is incompatible with the substantivalism it often appears to embrace in talking of the four-dimensional block universe. Each view is self-undermining, deep below the surface, and this

creates the deadlock — the puzzling appearance that each view has it right and yet each view has it wrong.

Perhaps the moving spotlight view, which is the least popular of the four positions in temporal ontology, is the closest to identifying the trap, for it makes these presuppositions (of substantivalism and dynamism) explicit parts of its view. And indeed, if one is going to try to avoid my objections and save static theory by taking dualism as a way out, then the moving spotlight view may well be the most reasonable view to take. That is, a static theorist should hold that the physical world is a static, substantivalist block, but there is a moving spotlight – our minds, which are not part of the block universe – that "lights up" each time of the block. In this way, one can save the static universe from the Flipbook Objection by divorcing phenomenal passage from the physical universe, and yet still keep that phenomenal passage as a real feature of the world in some sense. It just comes with the heavy price tags that dualism and substantivalism each carry. Temporal passage, as a completely mental phenomenon with no relation to the physical, will continue to be mysterious. And to keep substantivalism, one will have to reject Leibniz Equivalence, and either find a reason to either reject post-relativistic physics altogether, or accept radical indeterminism (not just incompleteness) in our physical theories.

5.2.2 On the ontology of objects

One might wonder what kind of ontology of (physical) objects this view commits me to. For, if I'm saying there are no physical objects, because they are just abstractions from properties, which are all processes, then it sounds like I have some version of a bundle theory in mind. (Compare 'How can there be change without something to change?' with 'How can there be redness without something that is red?') I acknowledge that this might be an implication of my view, and that I have not said much about the ontology of objects in this dissertation.

The table is made up of properties: hardness, color, weight, etc. This is how we pick out the table and apart from these, we cannot say anything about it. The hardness, color, and weight depend on molecule arrangements, temporally extended. The molecules themselves

are made up of elementary particles (particles which have no known component parts), which are themselves defined in terms of properties: for instance, spin. Spin depends on the mass and velocity of the object spinning; that is, we can say something is spinning if we identify something with mass and (rotational) velocity. (Spin is a special case of linear momentum.)

Mass is equivalent to energy, which is defined in modal and temporal terms: the ability to do work (and work is the ability to cause a change; to transmit energy some distance — note the circularity in the characterization, which is not mine). So something has mass iff it has the ability to cause a change. Velocity depends on speed and direction (relative to another moving body, in relativity theory); speed depends on *a change in* distance and time.

So, something has spin only if it has the ability to cause a change, *and* it changes. So, this bottom-level property is defined in terms of change.

There are other elementary particles, like photons, which are massless. These are even more clearly defined only in terms of change: it's a particle that always moves at the speed of light in a vacuum and represents the minimal amount of electromagnetic radiation. There is no substructure or mass to imagine as the 'bare' particle here; it's only defined in terms of its properties.

All physical properties represent some kind of change; therefore they are all temporally extended, in the same sense that change is temporally extended; and change is prior to objects because we cannot understand objects without reference to properties and we cannot understand properties without reference to change. So an object at an instant is nonsense. But objects are themselves prior to times. We abstract times from the changes we perceive and then we fill in that abstraction with smaller times to represent intervals that are below our perception threshold, in order to represent changes that are smaller than what we can perceive. So the at-at view of change is false: there is change, from which we derive the idea of a property, and then from there the idea of an object, and then the idea of a time; change is thus explanatorily and constitutively more fundamental than objects and times. Is it also existentially more fundamental? Yes, in the sense that objects and times are mind-dependent entities, while change is not. Change – process – — happenings are taking place in the world;

and we carve them up in a particular way.

So, I have a process-first ontology, but what ontology of objects this commits me to I am not sure; this deserves further exploration.

5.2.3 The problem of temporary intrinsics

I mentioned briefly, in Chapter 4, that projection-based accounts of our experiences as of passage seem to be based on Lewis' problematic set-up of the problem of temporary intrinsics. The problem of temporary intrinsics is the putative problem that one object – say, a lump of clay – can be shaped into a square at another moment, smashed into a ball at another moment, and yet we still consider the object to be the same lump of clay. That is, an object can have an intrinsic, non-relational property such as shape, which changes over time. But, according to Leibniz's law, this should mean that the smashed clay and the clay square are not the same object, for they do not have all the same intrinsic properties.

There is much debate about the proper way out of this problem, which has led to two different standard views about how objects maintain their identity over time: endurantism, according to which objects are wholly present at a time, and perdurantism, according to which objects are only partially present at a time — that is, the whole object is a sort of four-dimensional "worm" extended in spacetime, and what is present at a given moment is only a temporal "slice" of that object/worm.

The perdurantist deals with the problem of temporary intrinsics by reframing it entirely: the clay square and the smashed clay are just two different temporal slices of the clay worm, and so they do not need to be identical. This, of course, means that objects do not change over time: they are extended in time and only their temporal slices differ from each other; the whole object is made up of all of the different slices.

The endurantist generally tries to deal with the problem of temporary intrinsics by relativizing properties to times: that is, an object doesn't have the property of being square at t_1 and round at t_2, but has the property of being-square-at-t_1 and also has the property of being-round-at-t_2. So the object's properties are still able to change, at the cost of those

properties no longer being intrinsic but relational: they are relative to times.

This way of framing the problem is both ubiquitous and, in my view, seriously misguided. For one thing, Leibniz originally restricted his principle to substances; it was never meant to be a diagnostic test for identity in ordinary objects like lumps of clay, or people, or the like.[1] Second, and more urgently, the problem of temporary intrinsics relies on the assumption that at-at change is the correct view of change, which appears to rely on the assumptions that there are objects and that there are (substantivalist) times.

These seem like reasonable assumptions on the surface. I think all three are mistaken, at least in terms of what actually exists in the physical world — the concepts of times and objects are obviously useful models for understanding the world, and I am not proposing we stop discussing things in such terms, or utilizing at-at change as a model, in every arena. (Indeed, it would be very hard if not impossible to do so.) But if we are really trying to get down to the nuts and bolts of physical reality, these concepts deserve further scrutiny. As discussed in Chapters 2 and 3, there are reasons to dismiss all of them.

If at-at change is false, then it's not curious why an 'object' can change over time and still be the same object. This is because change should be understood as intrinsic to that object. What it is to be the ball of clay is to undergo process, including the process of being square and then being smashed into a ball. There are no times for its properties to be relativized to, as in the endurantist solution, but neither is it the case that the object does not change over time, as in the perdurantist solution. And, the object isn't "made up" of its temporal history in a way that means it is not wholly present at a 'time'. 'All there is' to the object when it is a square is being a square piece of clay; 'all there is' to the object when it is a smashed ball is being a smashed ball of clay. The times are abstractions from ways we perceive the clay as being. Since a given time t is an abstraction from the way the 'object' is, of course the object is fully present at that time, because that is what t consists of — for the object to be in such a state. But the object is an abstraction from change (from process), so what it is to be an object is to undergo process. There is the changing of the molecules that make up the

[1] See his *Discourse on Metaphysics*, section 9, for the original formulation.

clay, and we abstract 'square clay' from (part of) the changing, and then 't' from the 'square clay'. And, indeed, the 'molecules' are themselves abstracted from their own changing. It's process all the way down. So both the endurantist and the perdurantist get it right, and they both get it wrong. This is because they are trying to explain things in a way that is badly framed.

How can there be changing without something that changes? And how can we know that it changes except against the backdrop of something that does not change? These are two fundamental questions at issue here.

On the latter: this is an epistemic question, not a metaphysical question. In fact, I think it is exactly why we abstract times (and objects!) from change: because we are trying to create a useful distinction between (apparent states of) 'change' and (apparent states of) 'no change', when in fact there is no such thing as a state of no change. There's just, perhaps, 'more change' and 'less change'. There is a threshold below which we can no longer perceive change, as a consequence of our cognitive architecture. But that does not mean there is no change going on! We know that the molecules in what seems like a unmoving, sturdy table are still busy, busy, busy. But relativizing one apparent state to another apparent state helps us understand the world.

On the former: this is a bit like asking 'Why is there something rather than nothing?' It is a pseudo-problem that only arises against the background assumption that 'nothing' is the default state. Then there is a question of why 'something' should exist at all. If one assumes that 'something' is the default state, then the question does not arise. Similarly, 'How can there be changing without something that changes?' arises against the background assumption that there are objects which are ontologically prior to change. If we remove that assumption, then the question reveals itself as a pseudo-problem. And indeed, the only defense of the assumption that objects are ontologically prior to change is the idea that *what it is to change* is for an object to have a property at t_1 and to have a different property at t_2. That is, at-at change underwrites the question. And I've argued that there is good reason for thinking at-at change is an incorrect view of change. At any rate, at-at change is clearly an

abstraction from what we think we observe: states of 'change' and 'no change'. We observe a ball that is sitting on the table and appears not to be changing; we observe the ball dropping off the table; we say that a change has occurred. But we know, as I just said, that there are threshholds below which we no longer perceive any change. And, as I argued in my defense of the view that at-at change is incorrect, everything we know about the (physical) world involves change: our definitions of things like molecules, electromagnetism, etc., all invoke change. We have reason, in short, to think that change is ubiquitous in nature, and intrinsic to all we observe. It is only a small, and justifiable, leap to say that change is ontologically prior to all else. This does make it a primitive, which is part of why it is hard to wrap our heads around it — the rest is because our ordinary ways of talking about the world assume the concreteness of objects, times, and the like.

5.2.4 On physics and metaphysics

For many philosophers in the literature on time, the notion that the best current physics rules out the possibility of time's passage is an insurmountable hurdle over which any metaphysical argument in passage's favor cannot leap. Others, who are perhaps more sympathetic to metaphysics generally, still think metaphysics is on dangerous ground when it dares to contradict apparently established science. The following thoughtful quote from Sam Baron (2017) is illustrative of this view:

> [A particular proposal, involving an endorsement of a neo-Lorentzian physics in order to make temporal passage scientifically sensible] recommends a revision to science on philosophical grounds. For a Quinean naturalist, any such recommendation should be treated with suspicion. Weaker forms of naturalism permit philosophy to alter science in some cases. But even a relatively weak naturalist will have reason to pause before recommending the wholesale rejection of a well-established scientific theory. Of course, the extent to which it is permissible to reject a scientific theory for philosophical reasons depends on the epistemic status

> of those reasons. This brings us to the second problem: it is far from clear that the reasons for believing the dynamic theory of time can overthrow an established scientific theory. For some, the primary basis for believing the dynamic theory of time is that it is intuitive. The epistemic status of philosophical intuitions is notorious, however. For others, as noted, we should believe the dynamic theory of time because it marries with experience. But it remains unclear just how much evidential support our experiences provide for any particular theory of time.

This all seems rather sensible at first pass. But there is a great deal to unpack here that almost never gets unpacked in the literature.

First, what is "science" supposed to be? I have talked a lot about science and physics in this dissertation, but it's not as if "science" were some monolithic body of truths (and their clear entailments) which one could peruse to discover if one's metaphysics sit nicely with it or not (or, more pointedly, which one could take a hack-saw to in favor of one's metaphysical intuitions, even if one wanted to). Even locutions like "the best current science", which I used of necessity only moments ago, are vague at best upon examination. When we talk about "science" with respect to time's passage, we nearly always mean physics. And when we talk about "the best current physics", we nearly always mean something like "those theories (or parts of theories) of physics that most practicing physicists accept". But it is not at all clear that there is any such thing as "the theories (or parts of theories) that most practicing physicists accept".

To take a specific example: because of the inherent conflict between general relativity and quantum mechanics (that is, because general relativity is not good at predicting the behavior of very small scale systems) there are at present a wide variety of theories which propose to resolve this conflict — at least some of which are much more obviously compatible with a dynamic reality, which makes them germane to any theorizing about temporal passage.[2] As there are several camps of theory on this issue, however, it's unclear which one

[2]To give an example: Loop Quantum Gravity (LCG) is currently an theory under much excited discussion in both physics and physically-informed philosophy of time, as it seems to require relationalism; its formu-

is supposed to be "the best current physics". Moreover, if enough physicists embraced one of the theory camps such that there was a majority view, it's unclear when the epistemic status of that particular theory would suddenly increase relative to the others: at 51 percent of physicists embracing it? At 60 percent? At 70 percent? What if the rival views were just one homogenous group themselves, rather than several small camps? Is epistemic status such that a belief is reasonable in exact proportion to the number of people who actually believe in it? (Even if we replace "people" with "experts" in that last sentence, it strikes me as wrong-headed.)

Second, Baron comments that any methodological naturalist should be deeply concerned if philosophy recommends a revision to "science", and the reasoning seems to be that philosophical theories rest either on intuitions – which are supposed here to be unreliable – or experiences, which are also supposed to be suspect as evidence. This raises a number of questions:

1. Should we be methodological naturalists, and if so, why, and to what degree?

2. If philosophy is epistemically inferior to science because its theories rely on unreliable intuitions and experiences, what is it that the epistemically superior theories of science are supposed to be built off of — if not intuitions and experiences?

3. What is an "intuition"? Why are they considered unreliable?

4. Why are our experiences supposed to be doubtful as good evidence for our philosophical theories?

Each of these questions could probably be the subject of a dissertation in its own right. I will not address (1) here — I do not think it is relevant to the aims and scope of this dissertation, not least because I am *not* recommending that we engage in the "wholesale rejection of a well-established scientific theory". I have not, in fact, said that any physical

lation is background-independent, meaning its equations are not dependent upon the shape of spacetime or the value of any particular fields of spacetime.

theory is wrong; I only hold that we are interpreting these theories badly in many cases. *Nothing I've said in this dissertation is incompatible with (any form of) relativity theory*, as far as I can tell — I've only argued that we are unjustifiably reading a static temporal ontology off of certain mathematical models. The process view of passage does not require an absolute notion of simultaneity; to the contrary, I think it does not play well with such a notion, because on the process view, times are arbitrary, mind-dependent ways of carving up the world, and the changes in it. There can be no privileged present any more than there can be a privileged mind.

I briefly addressed (3) and (4) in chapter 4, pointing out that our experiences can tell us quite a lot about the world, if we examine what sorts of things must be true in order for us to have experiences as all, and that, if there is any such thing as an "intuition", it's not automatically worthless simply because it isn't absolutely truth-tracking — for neither are our experiences, insights, or reasoning. Intuition (and indeed, any kind of evidence) does not get drawn upon in a vacuum or left alone to stand as theory all by itself, but is utilized in a complicated web of decision-making and theorizing that, one hopes, produces something of worth. In other words, it is simply false that "garbage in, garbage out".

With respect to (2), I will say that I think it obvious that both science and philosophy draw upon the same kinds of evidence — that is, intuition, reasoning, and experience. These are, it seems to me, the main kinds of evidence that one can have for anything. And if it's not the case that the kinds of evidence used in scientific theorizing is epistemically superior, then if science is epistemically superior, that superiority must be located in its method instead, or perhaps in the kinds of questions it investigates. But if the epistemic superiority of science over philosophy is something derived from its method, then it is odd to point the finger at philosophy's kinds of evidence as the reason it should be held in lower epistemic regard. Further, a great many people before me have commented on the difficulty of identifying the "scientific method" or, for that matter, the philosophical one. So, what reasons do we have for thinking that science is epistemically superior? Are we left, for instance, only to point at its relative success with predicting things about the physical world? Then it seems to

me that we should only consider science epistemically superior with respect to its predictive power. Whether or not temporal passage exists is not obviously a matter of prediction, as neither side hopes to eventually observe passage. So, it's unclear that philosophy needs to tread lightly on the issue.

Moreover, I think that a great deal of confusion in the field has been brought about by uncritically 'accepting' the 'results of physics' — but the interpretation of those results often has pre-reflective metaphysical views about time "baked in". One salient example of the kind of baked-in view I'm talking about is spacetime substantivalism, which eternalists often either accept or appear to accept (in the guise of their four-dimensionalism) because it is generally thought (incorrectly, by my lights) to be required by Special Relativity. And eternalists sometimes argue that presentists cannot accept the existence of a spacetime manifold, since the manifold necessarily has parts that don't exist according to the presentist (i.e., past and future spacetime points). Since the 'best current physics' requires something presentism cannot accept, we ought to reject presentism. Or so the story typically goes. But there's a deep problem here: since the Lorentz transforms that form the basis of Minkowski spacetime are transforms of the spacetime coordinates from one reference frame to another, more than one location in spacetime is already assumed; they are the things which Minkowski spacetime aims to model to begin with. It is unwarranted to assign existential import to something (spacetime locations, and thus the "equally real" existence of past and future times) just because we are studying the structure of it. The very notion of a four-dimensional spacetime, if treated with existential import, already assumes eternalism to begin with; why should we then be surprised that it is incompatible with presentism? Such an argument is obviously circular: eternalism is true (and presentism is false) because eternalism is true (and presentism is false); it gets past so many only because it is couched as "Eternalism is true (and presentism is false) because the best current physics requires eternalism".

The upshot here is not supposed to be that substantivalism is false, nor that presentism is true, nor that we should never listen to science; only that arguments that proceed from 'the best current physics' to this or that metaphysical position should be treated with great

caution, in order to avoid unintentional circularity, because our interpretations of scientific results often carry metaphysical baggage. So we cannot simply read the answers to fundamental metaphysical questions straight off of the results of physics. The point is made well by Markosian (2004):

> It is fashionable nowadays to give arguments from scientific theories to philosophical conclusions. I don't have a problem with this approach in general. But I think it is a seldom-observed fact that when people give arguments from scientific theories to philosophical conclusions, there is usually a good deal of philosophy built into the relevant scientific theories. ... And I think it very rarely happens that we are presented with a genuine case of science versus philosophy.

BIBLIOGRAPHY

Alexander, H.G., ed. 1956. *The Leibniz-Clarke Correspondence.* Manchester University Press.

Alper, Joseph S., and Mark Bridger. 1997. "Mathematics, model and Zeno's paradoxes." *Synthese: An International Journal for Epistemology, Methodology and Philosophy of Science* 110 (1): 143–166.

Antonopoulos, Constantin. 2004. "Moving without being where you're not; A non-bivalent way." *Journal for General Philosophy of Science* 35 (2): 235–259.

Aristotle. 1983. *Physics, Book IV.* Translated by Edward Hussey. Oxford: Clarendon Press.

Arthur, Richard T. W. 2019. *The Reality of Time Flow: Local Becoming in Modern Physics.* The Frontiers Collection. Springer.

Baron, Sam. 2017. "Feel the flow." *Synthese* 194 (2): 609–630.

Baron, Sam, Kristie Miller, and Jonathan Tallant. 2023. "Presentism and representation: saying it without words." *Synthese* 201 (2): 1–33.

Belot, Gordon. 2005. "Dust, time and symmetry." *British Journal for the Philosophy of Science* 56 (2): 255–291.

Benovsky, Jiri. 2010. "The Relationist and Substantivalist Theories of Time: Foes or Friends?" *European Journal of Philosophy* 19 (4): 491–506.

———. 2013. "The present vs. the specious present." *Review of Philosophy and Psychology* 4 (2): 193–203.

———. 2016. "Endurance, Dualism, Temporal Passage, and Intuitions." *Review of Philosophy and Psychology* 7:851–862.

Bergson, Henri. 1911. *Creative Evolution.* Palgrave-Macmillan.

Bigelow, John. 1991. "Worlds Enough for Time." *Nous* 25 (1): 1–19.

Boccardi, Emiliano. 2015. "If it ain't moving it shall not be moved." *Topoi: An International Review of Philosophy* 34 (1): 171–185.

———. 2017. "The Passage of Time and its Enemies: an Introduction to Time and Reality II." *Rev. Int. Fil. Campinas* 40 (1): 5–41.

———. 2018. "Time as motion." *Metaphysica: International Journal for Ontology and Metaphysics* 19 (1): 157–183.

———. 2019. "Change and Contradiction: A Criticism of the Hegelian Account of Motion." In *Seminário Lógica no Avião,* edited by Rodrigo Freire Edgar Almeida and Alexandre Costa-Leite, 135–148. Universidade de Brasilia.

Bourne, Craig. 2006. *A Future for Presentism.* Oxford University Press.

Braddon-Mitchell, David. 2004. "How do we know it is now now?" *Analysis* 64, no. 3 (July 1, 2004): 199–203. https://doi.org/10.1093/analys/64.3.199.

Briggs, R. A., and Graeme A. Forbes. 2017. "The Growing-Block: just one thing after another?" *Philosophical Studies* 174 (4): 927–943.

Brighouse, Carolyn. 2020. "Confessions of a (Cheap) Sophisticated Substantivalist." *Foundations of Physics* 50 (4): 348–359.

Broad, C.D. 1923. *Scientific Thought.* London: Kegan Paul, Trench, Trubner & Co, Ltd.

———. 1938. *An Examination of McTaggart's Philosophy.* Vol. II. Cambridge: Cambridge University Press.

Brown, Harvey R. 1997. "On the role of special relativity in general relativity." *International Studies in the Philosophy of Science* 11 (1): 67–81.

Callender, Craig. 2011. "Introduction." In *The Oxford Handbook of Philosophy of Time,* edited by Craig Callender. Oxford University Press, April 7, 2011. https://doi.org/10.1093/oxfordhb/9780199298204.003.0001.

———. 2017. *What makes time special?* Oxford: Oxford University Press.

———. 2019. "Time, flow, and space." *Behavioral and Brain Sciences* 42.

Calosi, Claudio, and Vincenzo Fano. 2014. "Arrows, balls and the metaphysics of motion." *Axiomathes: An International Journal in Ontology and Cognitive Systems* 24 (4): 499–515.

Cameron, Ross P. 2015. *The Moving Spotlight: An Essay on Time and Ontology.* Oxford University Press.

Chalmers, David. 2005. "Primitive Concepts." Workshop on Concepts and Conceptual Analysis, ANU. https://consc.net/slides/primitive.pdf.

Coope, Ursula. 2005. *Time for Aristotle: Physics IV.10-14.* Oxford University Press.

Corish, Denis. 2015. "Time as relative." *Philosophy: The Journal of the Royal Institute of Philosophy* 90 (353): 369–391.

Correia, Fabrice, and Sven Rosenkranz. 2018. *Nothing to Come: A Defence of the Growing Block Theory of Time.* Springer Verlag.

Craig, William Lane. 2000. "The extent of the present." *International Studies in the Philosophy of Science* 14 (2): 165–185.

———. 2001. "McTaggart's paradox and temporal solipsism." *Australasian Journal of Philosophy* 79 (1): 32–44.

Crisp, Thomas M. 2004. "On presentism and triviality." *Oxford Studies in Metaphysics* 1:15–20.

Curiel, Erik. 2014. "On the Existence of Spacetime Structure." *British Journal for the Philosophy of Science.*

Dainton, Barry. 2011. "Time, passage, and immediate experience." In *The Oxford Handbook of Philosophy of Time,* edited by Adrian Bardon, 381–418. Oxford: Oxford University Press.

Dasgupta, Shamik. 2015. "Substantivalism vs Relationalism About Space in Classical Physics." *Philosophy Compass* 10 (9): 601–624.

Deasy, Daniel. 2015. "What is presentism?" *Nous* 50 (4): 1–20.

Demarest, Heather. 2015. "Fundamental properties and the laws of nature." *Philosophy Compass* 10 (5): 334–344.

Deng, Natalja. 2013. "On explaining why time seems to pass." *The Southern Journal of Philosophy* 51 (3): 367–382.

———. 2017. "What is temporal ontology?" *Philosophical Studies* 175 (3): 793–807.

Descartes, Renee. 1983. *Principles of Philosophy.* Translated by V.R. Miller and R.P. Miller. Dordrecht: Kluwer Academic Publishers.

Dorato, Mauro. 2000. "Substantivalism, Relationism, and Structural Spacetime Realism." *Foundations of Physics* 30 (10): 1605–1628.

———. 2006. "The irrelevance of the presentist/eternalist debate for the ontology of Minkowski spacetime." In *The ontology of spacetime,* edited by Dennis Dieks, 93–109. Elsevier.

Duerr, Patrick M., and Claudio Calosi. 2021. "The general-relativistic case for super-substantivalism." *Synthese* 199 (5): 13789–13822.

Dummett, Michael. 2000. "Is time a continuum of instants?" *The Journal of the Royal Institute of Philosophy* 75 (294): 497–515.

Earman, John, and John Norton. 1987. "What Price Spacetime Substantivalism? The Hole Story." *British Journal for the Philosophy of Science* 38 (4): 515–525.

Effingham, Nikk. 2011. "Temporal parts and time travel." *Erkenntnis: An International Journal of Analytic Philosophy* 74 (2): 225–240.

Einstein, Albert. 1918. "Dialogue about Objections to the Theory of Relativity." In *The Collected Papers of Albert Einstein, Volume 7 (English): The Berlin Years: Writings, 1918-1921.* Translated by Alfred Engel, 697–702.

———. 1921. *Relativity. The Special and General Theory.* Routledge.

———. 1923. "On the electrodynamics of moving bodies." In *The Principle of Relativity,* 35–65. Dover Publications.

———. 1934. "On the method of theoretical physics." *Philosophy of Science* 1 (2): 163–169.

Field, Hartry. 1984. "Can We Dispense with Space-Time?" *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association* 1984:33–90.

Fine, Kit. 2001. "The question of realism." Publisher: Mpublishing, *Philosophers' Imprint* 1:1–30.

Forbes, Graeme A. 2016. "The Growing Block's past problems." *Philosophical Studies* 173 (3): 699–709.

Forrest, Peter. 2004. "The real but dead past: A reply to braddon-Mitchell." *Analysis* 64 (4): 358–362.

Frischhut, Aikiko. 2015. "What experience cannot teach us about time." *Topoi* 34:143–155.

Frischhut, Akiko. 2012. "The Experience of Temporal Passage." Dissertation, Universite de Geneve, University of Glasgow. https://philpapers.org/archive/FRITEO-27.pdf.

Gilmore, Cody, Damiano Costa, and Claudio Calosi. 2016. "Relativity and three four-dimensionalisms." *Philosophy Compass* 11 (2): 102–120.

Graziani, Ernesto, and Francesco Orilia. 2021. "Temporal ontology: tenselessness and quantification." *Synthese* 198, no. 3 (March 1, 2021): 2821–2847. https://doi.org/10.1007/s11229-019-02248-z.

Griffiths, Robert B. 2015. "Consistent quantum measurements." *Studies in History and Philosophy of Science Part B* 52:188–197.

Gruber, Ronald P., and Richard A. Block. 2013. "The Flow of Time as a Perceptual Illusion." *The Journal of Mind and Behavior* 34 (1): 91–100.

Hall, A.R., and Marie Boas Hall, eds. 1962. *Unpublished Scientific Papers of Isaac Newton.* Cambridge: Cambridge University Press.

Hochstetter, Kenneth. 2015. "Stages can't act." *Journal of Philosophical Research* 40:227–236.

Hoefer, Carl. 1994. "Einstein's struggle for a Machian gravitation theory." *Studies in History and Philosophy of Science Part A* 25 (3): 287–335.

Hoefer, Carl, Nick Huggett, and James Read. 2023. "Absolute and Relational Space and Motion: Classical Theories." In *The Stanford Encyclopedia of Philosophy,* Spring 2023, edited by Edward N. Zalta and Uri Nodelman. Metaphysics Research Lab, Stanford University. https://plato.stanford.edu/archives/spr2023/entries/spacetime-theories-classical/.

Huggett, Nick, Carl Hoefer, and James Read. 2023a. "Absolute and Relational Space and Motion: Post-Newtonian Theories." In *The Stanford Encyclopedia of Philosophy,* Summer 2023, edited by Edward N. Zalta and Uri Nodelman. Metaphysics Research Lab, Stanford University. https://plato.stanford.edu/archives/sum2023/entries/spacetime-theories/.

———. 2023b. "Absolute and Relational Space and Motion: Post-Newtonian Theories." In *The Stanford Encyclopedia of Philosophy,* Summer 2023, edited by Edward N. Zalta and Uri Nodelman. Metaphysics Research Lab, Stanford University. https://plato.stanford.edu/archives/sum2023/entries/spacetime-theories/.

Ingthorsson, R.D. 2016. *McTaggart's Paradox.* Routledge: New York.

Janssen, Michel. 2012. "The twins and the bucket: How Einstein made gravity rather than motion relative in general relativity." *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics* 43 (3): 159–175.

Kearns, John T. 1970. "Substance and Time." *Journal of Philosophy* 67:277–289.

Kleinschmidt, Shieva. 2017. "Refining four-dimensionalism." *Synthese: An International Journal for Epistemology, Methodology and Philosophy of Science* 194 (11): 4623–4640.

Kroll, Nicky. 2020. "Passing Time." *Erkenntnis* 85:255–268.

Lange, Marc. 2002. *An Introduction to the Philosophy of Physics: Locality, Fields, Energy, and Mass.* Blackwell.

Le Bihan, Baptiste. 2020. "String Theory, Loop Quantum Gravity and Eternalism." *European Journal for Philosophy of Science* 10:17.

Le Poidevin, Robin. 1997. "Time and the static image." *Philosophy: The Journal of the Royal Institute of Philosophy* 72 (280): 175–188.

———. 2002. "Zeno's arrow and the significance of the present." In *Time, Reality and Experience,* edited by Craig Callender, 57–72. Cambridge: Cambridge University Press.

Lehmkuhl, Dennis. 2018. "The Metaphysics of Super-Substantivalism." *Noûs* 52 (1): 24–46.

Lewis, David. 1983. "New work for a theory of universals." *Australasian Journal of Philosophy* 61:343–377.

Loss, Roberto. 2022. "How the Block Grows." *American Philosophical Quarterly* 59 (4): 377–389.

Lumbreras Sancho, Sara. 2009. "Space and time ontology: New models for new physics." *Pensamiento: Revista De Investigación e Información Filosofíca* 65 (246): 1141–1146.

Maitzen, Stephen. 2017. "Substantial change: Continuous, consistent, objective." *Journal of Philosophy* 114 (10): 551–562.

Markosian, Ned. 2004. "A Defense of Presentism." *Oxford Studies in Metaphysics* 1:47–82.

Martens, Niels C. M. 2019. "The Metaphysics of Emergent Spacetime Theories." *Philosophy Compass* 14 (7).

Mazzola, Claudio. 2012. "Where Does Time Go?" *Disputatio* 4 (33): 485–494.

———. 2015. "On continuity and endurance." *Acta Analytica: International Periodical for Philosophy in the Analytical Tradition* 30 (2): 133–147.

McCall, Storrs. 1976. "Objective Time Flow." *Philosophy of Science* 43 (3): 337–62.

McDonough, Jeffrey K. 2021. "Leibniz's Philosophy of Physics." In *The Stanford Encyclopedia of Philosophy,* Fall 2021, edited by Edward N. Zalta. Metaphysics Research Lab, Stanford University. https://plato.stanford.edu/archives/fall2021/entries/leibniz-physics/.

McLaughlin, William I., and Sylvia L. Miller. 1992. "An epistemological use of nonstandard analysis to answer Zeno's objections against motion." *Synthese: An International Journal for Epistemology, Methodology and Philosophy of Science* 92 (3): 371–384.

McTaggart, J.M.E. 1908. "The unreality of time." *Mind* 17 (68): 457–474.

Meincke, Anne Sophie. 2019. "The Disappearance of Change: Towards a Process Account of Persistence." *International Journal of Philosophical Studies* 27 (1): 12–30.

Merricks, Trenton. 2007. *Truth and Ontology.* Oxford University Press.

Meyer, Ulrich. 2005. "Dummett on the time-continuum." *Philosophy: The Journal of the Royal Institute of Philosophy* 80 (311): 135–140.

———. 2015. "Tense logic." *Philosophy Compass* 10 (6): 406–419.

Miller, Kristie. 2005. "Blocking the path from vagueness to four dimensionalism." *Ratio: An International Journal of Analytic Philosophy* 18 (3): 317–331.

———. 2013. "Presentism, eternalism, and the growing block." In *A Companion to the Philosophy of Time,* edited by Heather Dyke and Adrian Bardon, 345–364.

———. 2019. "The cresting wave: a new moving spotlight theory." *Canadian Journal of Philosophy* 49 (1): 94–122.

Morganti, Matteo. 2017. "Relationism about Time and Temporal Vacua." *Philosophy* 92 (1): 77–95.

———. 2020a. "Fundamentality in metaphysics and the philosophy of physics. Part I: Metaphysics." *Philosophy Compass* 15 (7). https://compass.onlinelibrary.wiley.com/doi/abs/10.1111/phc3.12690.

———. 2020b. "Fundamentality in metaphysics and the philosophy of physics. Part II: The philosophy of physics." *Philosophy Compass* 15 (10). https://compass.onlinelibrary.wiley.com/doi/abs/10.1111/phc3.12703.

Morganti, Matteo, and Tuomas Tahko. 2017. "Moderately Naturalistic Metaphysics." *Synthese* 194:2557–2580.

Newton, Isaac. 1726. *Philosophiae Naturalis Principia Mathematica.* 3rd. Edited by Alexandre Koyré, I. Bernard Cohen, and Anne Whitman. Cambridge, MA: Harvard University Press.

———. 1932. "Scholium." In *Philosophiae Naturalis Principia Mathematica, Bk. 1,* edited by Florian Cajori, translated by Andrew Motte. Berkeley: University of California Press.

North, Jill. 2018. "A new approach to the relational-substantival debate." *Oxford Studies in Metaphysics* 11:3–43.

Norton, John D., Oliver Pooley, and James Read. 2023. "The Hole Argument." In *The Stanford Encyclopedia of Philosophy,* Summer 2023, edited by Edward N. Zalta and Uri Nodelman. Metaphysics Research Lab, Stanford University. https://plato.stanford.edu/archives/sum2023/entries/spacetime-holearg/.

Paul, L.A. 2010. "Temporal Experience." *The Journal of Philosophy* CVII (7): 333–359.

———. 2012. "Metaphysics as modeling: the handmaiden's tale." *Philosophical Studies* 160 (1): 1–29.

Perovic, Katarina. 2016. "A Neo-Armstrongian Defense of States of Affairs: A reply to Vallicella." *Metaphysica* 17 (2): 143–161.

———. 2019a. "Three Varieties of Growing Block Theory." *Erkenntnis* 86:623–645.

———. 2019b. "What is a fourdimensionalist to do about temporally extended properties?" *European Journal of Philosophy* 27 (2): 441–452.

Petersen, Thorben. 2016. "The grounding problem for eternalism." *Philosophical Studies* 173 (7): 1819–1852.

Pezet, Robert E. 2020. "Duration Enough for Presentism." *Axiomathes* 30 (4): 391–421.

Phillips, Ian. 2010. "Perceiving temporal properties." *European Journal of Philosophy* 18 (2): 176–202.

Pickering, F.R. 1978. "Aristotle on Zeno and the Now." *Phronesis: A Journal of Ancient Philosophy* 23:253–257.

Plato. 2000. *Timaeus.* Translated by D.J. Zeyl. Indianapolis and Cambridge, MA: Hackett Publishing Co.

Pleitz, Martin. 2016. "Solving Prior's problem with a Priorean tool." *Synthese: An International Journal for Epistemology, Methodology and Philosophy of Science* 193 (11): 3567–3577.

Pooley, Oliver. 2013a. "Relativity, the Open Future, and the Passage of Time." *Proceedings of the Aristotelian Society* 113 (3): 321–363.

———. 2013b. "Substantivalist and Relationalist Approaches to Spacetime." In *The Oxford Handbook of Philosophy of Physics.* Oxford: Oxford University Press.

Price, Huw. 2009. "The Flow of Time." In *The Oxford Handbook of Philosophy of Time,* edited by Craig Callender. Oxford University Press.

Prosser, Simon. 2007. "Could we experience the passage of time?" *Ratio* 20 (1): 75–90.

———. 2012. "Why Does Time Seem to Pass?" *Philosophy and Phenomenological Research* 85 (1): 92–116.

Quinn, P.L. 1979. "Existence throughout an interval of time, and existence at an instant of time." *Ratio: An International Journal of Analytic Philosophy* 21:1–12.

Read, Rupert. 2002. "Is 'what is time?' a good question to ask?" *Philosophy: The Journal of the Royal Institute of Philosophy* 77 (300): 193–209.

Riggs, Peter J. 2017. "Is There a Spatial Analogue of the Passage of Time?" *Philosophy and Cosmology* 18:12–21.

———. 2018. "Physical Time in Perspective." *Interalia Magazine* 43 (July).

Roberts, Bryan W. 2020. "Regarding 'Leibniz Equivalence'." *Foundations of Physics* 50 (4): 250–269.

Romero, Gustavo E. 2015. "Present Time." *Foundations of Science* 20 (2): 135–145.

———. 2017. "On the Ontology of Spacetime: Substantivalism, Relationism, Eternalism, and Emergence." *Foundations of Science* 22 (1): 141–159.

Rynasiewicz, Robert. 2022. "Newton's Views on Space, Time, and Motion." In *The Stanford Encyclopedia of Philosophy,* Spring 2022, edited by Edward N. Zalta. Metaphysics Research Lab, Stanford University. https://plato.stanford.edu/archives/spr2022/entries/newton-stm/.

Savitt, Steven. 2006. "Presentism and eternalism in perspective." In *The Ontology of Spacetime I,* edited by Dennis Dieks. Elsevier.

Savitt, Steven F. 2018. *In Search of Passing Time.* https://philsci-archive.pitt.edu/14823/1/In%20Search%20of%20Passing%20Time.pdf.

Shoemaker, Sydney. 1969. "Time without change." *Journal of Philosophy* 66 (12): 363–381.

Sider, T. 1996. "All the world's a stage." *Australasian Journal of Philosophy* 74 (3): 433–453.

Sider, Theodore. 2001. *Four Dimensionalism: An Ontology of Persistence and Time.* Oxford University Press.

———. 2006. "Quantifiers and temporal ontology." *Mind* 115 (457): 75–97.

Sklar, Lawrence. 1974. *Space, Time, and Spacetime.* University of California Press.

Skow, Bradford. 2011. "Why Does Time Pass?" *Noûs* 46 (2): 223–242.

———. 2015. *Objective Becoming.* Oxford University Press UK.

Sloan, David. 2015. "Calling time on digital clocks." *Studies in History and Philosophy of Science Part B* 52:62–68.

Smolin, Lee. 2015. "Temporal Naturalism." *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics* 52 (A): 86–102.

Steward, Helen. 2015. "What is a continuant?" *Aristotelian Society: Supplementary* 89:109–123.

Stoneham, Tom. 2009. "Time and truth: The presentism-eternalism debate." *Philosophy* 84 (2): 201–218.

Stuchlik, Joshua M. 2003. "Not all worlds are stages." *Philosophical Studies: An International Journal for Philosophy in the Analytic Tradition* 116 (3): 309–321.

Svarný, Petr. 2015. "Does branching explain flow of time or the other way around?" *Synthese* 192 (7): 2273–2292.

Swinburne, Richard. 1996. "The beginning of the universe and of time." *Canadian Journal of Philosophy* 26 (2): 169–189.

Tallant, Jonathan. 2009. "Presentism and Truthmaking." *Erkenntnis* 71 (3): 407–16.

Taylor, Richard. 1960. "Pure becoming." *Australasian Journal of Philosophy* 38, no. 2 (August): 137–143. Accessed April 7, 2023. http://www.tandfonline.com/doi/abs/10.1080/00048406085200141.

———. 1974. "Time and Eternity." In *Metaphysics,* Second, 81–90. Englewood Cliffs, New Jersey: Prentice-Hall.

Teitel, Trevor. 2022. "How to Be a Spacetime Substantivalist." *Journal of Philosophy* 119 (5): 233–278.

Tooley, Michael. 1997. *Time, Tense, and Causation.* Oxford University Press.

Tulenheimo, Tero. 2016. "Worlds, times and selves revisited." *Synthese: An International Journal for Epistemology, Methodology and Philosophy of Science* 193 (11): 3713–3725.

Whitehead, Alfred North. 1920. *The Concept of Nature: The Tarner Lectures Delivered in Trinity.* College: Dover Publications.

———. 1929. *Process and Reality: An Essay in Cosmology.* Free Press.

Wilson, Jessica M. 2014. "No Work for a Theory of Grounding." *Inquiry: An Interdisciplinary Journal of Philosophy* 57 (5): 535–579.

Zimmerman, Dean. 1996. "Persistence and presentism." *Philosophical Papers* 25 (2): 115–126.