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Time: A Measure of Change

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Time: A Measure of Change

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Abstract

This dissertation examines the metaphysical nature of time by drawing on literature in epistemology of measurement. Using such literature, I defend an account of time as a measure of change. I use literature on measurement to critique other metaphysical accounts of time and argue that some current metaphysical accounts of time are inadequate as accounts *of time*. The inadequacies we find in these accounts of time along with various other demands we have of an account of time push us further towards accepting the account of time I offer. While I defend a particular account of time, adopting that account is not a prerequisite for recognizing the valuable practice of using literature on measurement in conversations about the nature of time. Consequently, this dissertation can be understood as having a two fold purpose: 1) a meta-argument for the practice of using literature of measurement to examine metaphysical conversations about time and 2) providing an example of this recommended practice through the defense of a particular account of time, which draws on said literature.

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Chapter I: Introduction

Most of us accept that time is real. It is explaining what we mean by time and in what sense we think it is real that proves tricky. I argue that time is not a fundamental reality of the world but is rather a means of measuring a fundamental reality, change. If we take time not as fundamentally independent of us, the observer, but as a construct for measuring the objective world, then our current uses of time make more sense. I draw on recent work in measurement theory to develop the idea that time is nothing more than a measure of change, and, in doing so, I also demonstrate the value of using literature on measurement in metaphysical discussions of time. On closer inspection of some metaphysical accounts of time, it appears that some, if not many, of those accounts are insufficiently robust as accounts of time and perhaps are not even accounts *of time*. If that observation holds, then we need an account of time and I offer one.

Accepting Eran Tal's model-based account of time keeping practices, I argue that one way we might adjudicate between the apparent construction of time and the intuition that time is a fundamental reality is to understand time as a constructed measure of a real thing, namely change. The idea that time is not a fundamental feature of the world and not entirely independent of the observer, is not new, nor is the idea that time is some how inextricably tied up with change. However, what I offer are new insights, drawn from measurement theory, into how we might cash out both the reality and unreality of time as well as the way in which it is tied to change.

By working out what it might mean to understand time as a measure, we gain a means of understanding and organizing the often disparate accounts of time. Although, I present a specific account—an interesting way in which to understand time as a measure of change—that account is hardly the primary point of this project. The overarching point that ought to remain in the foreground, whether a person agrees or disagrees with this specific account, is that drawing on measurement theory is not only an underdeveloped practice, but a quite valuable one for evaluating metaphysical accounts of time and moving these accounts beyond their somewhat stagnant current debates.

Briefly, in chapter two, I present literature on epistemology and measurement issues in time-keeping. Chapter three, I turn to consider an account of change as the reality that we aim to measure. In chapter four, I present three case studies in metaphysics. Finally, I conclude by arguing that given the shortcomings of some metaphysical accounts of time and the uses of time in science, adopting the view that time is a measure of change is not only appealing but also allows us to retain the most important and interesting parts of our current debates on time while providing a better account of time. In the remainder of this introduction I provide an extended outline.

In the second chapter of this book I present work on epistemology of measurement and on the standardization of the second. While we often view measurement as a straightforward collection of data on which we build our more complex scientific theories, measurement is as theoretically and empirically complex as any other branch of science. Issues of reliability, standardization, calibration, margins of error, and on our list goes, turn out to require extensive philosophical examination and justification. In metrology, we immediately face the question of how much humans artificially impose

tidy measures on untidy realities, constructing the realities for which they search, versus simply observing and discovering un-manipulated regularities in nature by which to define measurements. This question of construction versus discovery is a question applicable to more than one unit of measure, however, since this is a project about time, I focus on time and measuring the second. Using atomic clocks and the process of standardizing the second as a specific example, I begin by explaining some of the processes used and required in standardizing atomic clocks.

To that end, subsection one provides a brief description of the mechanics of atomic clocks, considers the regular time discrepancies that arise between standard setting clocks, and then shows the process of calculating and creating agreement between these differing clocks. As we consider the ways in which we arrive at agreement in our data between clocks that regularly disagree with one another, questions arise about the constructive role of the observer in arriving at data outcomes and about what drives our science of time (social, economic, political, theoretical, aims, desires, empirical knowledge and facts, etc.). Subsection two turns to consider these questions. In what will, for this paper, be called a realist versus constructivist debate, though it is apart of the more broad realist versus anti-realist conversation, the main question is whether our standards of measure are based on social selections of pre-existing regularities or whether we construct regularities by which we then measure. Do we find actual regularities in the world and then shape our measures to those regularities as the realists argue or do we simply mold our data to fit constructed regularities?

Responding to this debate, in subsection three, Eran Tal argues that we must re-visualize core concepts like stability in order to understand that both realist and

constructive accounts of time capture something important about our measurement practices. Instead of entirely alienating or embracing either side of the debate, Tal takes a non-traditional approach to the debate by suggesting that we adopt a model based notion of time by which we can understand our standard second as a humanly developed measurement informed by and adapted to the realities of raw data. If we shift to a model based account we understand the process of measurement as a process of adjudicating between idealized standards and raw data via models. Models are able to take our idealized standards that do not match up to the less than ideal realities we observe in the world, and then de-idealize our standards by accounting for the imperfections and irregularities of raw data in order to develop the real world versions of our idealized standards. With respect to time and time-keeping, since time is not a thing that science can in any sense directly manipulate, measuring time ends up a process of measuring other things. Moreover, it turns out that our ideal second is, in part, a constructed standard and, in part, based on the ideal operational description of the changes in energy levels of a cesium atom. We do not ‘measure’ our actual clocks against our ideal, rather we measure them against the ideal *operation description* that we would like them to satisfy, namely, that all clocks are perfectly synchronized. Of course, measured against this ideal operational description, they come up short. If all we have of time is a created idealized standard and raw data regarding the change in the energy of atoms, a natural question to ask is whether we are using units of change to measure time or whether, more simply, time is the name we give to our measure of change. I suggest the later.

In the third chapter, I present an account of change that draws on Aristotelian metaphysics. I suggest that time is a measure of some other real thing: change. While

we might work up any number of accounts of change, I suggest that we use an account of change cashed out in terms of potential and actualization. One compelling reason to draw on Aristotelian accounts of change is that Aristotle defines change without reference to time. With no pretense of being a scholar of Aristotle, I offer two distinct Aristotelian inspired accounts of change as examples of the sorts of accounts that we might use to cash out this idea of time as a measure of change. The first account, drawing on Ursula Coope's work, suggests that change is the incomplete actuality of potential of being. According to her interpretation of Aristotle, change occurs as a thing's potential is coming into existence, but is not yet fully realized. Once the potential for being is realized, that particular change is now complete. The second account, from Andreas Anagnostopoulos, presents change as the proper activity of a thing's potential. Change is simply *doing* the activity that is proper to the *telos* of a thing's potential. Where Coope's account is concerned with the process of actualization, Anagnostopoulos' account is concerned with the doing of activities. What activity properly moves a thing with a potential for x towards the actual *telos* of x ? Whatever that activity is, doing it just is what it means for a thing to change. Change becomes the activity that moves a thing from the mere potential for x to x -ness. Only two things are required for my purposes: 1) an account of change that does itself not rely on an account of time (to make feasible the claim that time is nothing more than a measure of change) and 2) an account of change that might be a useful reference point in later conversations.

In the fourth chapter of this dissertation, I present three case studies where I use literature on measurement practices to consider metaphysical conversations about time. In the first case, I consider Shoemaker's account of time without change. Here I argue,

first, that Shoemaker's account is primarily aimed at the epistemic possibility of persons, like us, reasonably claiming to know of changeless periods of time in their unique world. Second, I argue that because he fails to properly appreciate the complexity of the observer's role in measurement, he has not provided us sufficient reason, in his thought experiment, to think that persons in that world would reasonably conclude that time, without change, is passing.

For the second case study, I use a brief account of presentism, presented by A.N. Prior, to demonstrate the shifts in backing assumptions that occur between conversations about time in metaphysics and in physics. Theorists engaging in such conversations are often insufficiently aware of the theory-laden aspects of the language they use. As a result of theorists being unaware, they often use language borrowed from another discipline, without fully appreciating the assumptions and implications those terms bring with them. Theorists must recognize not only that specific practices have developed technical uses for their language, in what some have coined as licensing (Boesch, 2017), but also that conversations between physics and metaphysics will require extensive attention to backing assumptions if they are to successfully engage one another.

In the third case study of chapter four, I argue that presentists' insufficiently define the present, or 'the now'. Because presentists often do not recognize the work they must do to notice the background assumptions implied by the terms that they borrow from fields such as physics, they also fail to recognize that their accounts of the present are not sufficiently robust to serve as an account of time. Questions about the duration of the present want addressing and the presentist's account of time is not in a position to address those questions. Provided that presentists are in fact after an account of time,

they have further work to do before they can claim to provide an account of time that does the work needed. However, if they are not aiming to provide an account of time, then they may have relatively little work to do. Time as a measure of change is a more useful and robust account of time. Presentists could adopt this account and doing so would further enable them to take advantage of time as a tool. The point and usefulness of a tool is that we can adapt it to our purposes. In the case of time, we can adapt it to all sorts of conversations about change, such as physical and metaphysical.

In chapter five, I conclude my dissertation by suggesting that some, if not many, metaphysical accounts of time are actually about change. Presentism, for example, is more profitably understood as concerned with change and what exists, rather than with time. Therefore, presentists might choose to accept the more robust account of time that I provide without sacrificing much of their current debate or account. Viewing time as a measure of change is attractive because it allows us to both preserve what is worth preserving in these disparate conversations about time and also allows us to reconcile these conversations. We can provide a unified account of what we see happening in conversations about time, value the differences, and also become clearer about what each of those conversations is actually aiming at and able to accomplish.

Adopting this account of time opens the door to all sorts of further work and research. In addition to tidying up our current conversations and language about time, we will also find substantive cross-disciplinary work concerning questions about change, as regards existence and causation, to name a few, that span physical, mathematical, and metaphysical spaces. Moreover, if it is the case that time is nothing more than a measure of change, then we should expect to find that, even where we aim to develop a robust

account of time as real, such an account will persistently reduce to a discussion of some aspect of change.

Chapter II: The Science of Time

“A man with one clock is sure of the time; a man with two clocks never is.” *Anon*

What is time? Is it a notion we construct or is it a mind-independent reality? While we usually admit that explaining time is quite a complex, even confusing project, we often make the mistake of thinking that measuring it is not. Measurement, mistakenly, becomes the simple project in which scientists go out and find some empirical regularity and then use it to count off seconds. A thorough understanding of measurement practice, as this chapter aims to show, provides metaphysicians with reasons to question the ontological status of time. While measurement practices and theories do not prevent one from viewing time as real, when we take them seriously we may find that an account of time as a mere measure of change turns out a better fit for what we observe around us than do other accounts of time.

The first section of this chapter explains the practice of measuring time via atomic clocks. The second section considers two common accounts of measurement theory: social construction versus data-driven measurement. Section three introduces a model-based account of measurement that synthesizes both the social and data-driven accounts. Finally, in section four, I suggest that the model-based account of measuring time holds interesting implications for metaphysical accounts of time.

Tal regularly references theory-ladenness but he does not have in mind Kuhn's account of theory-ladenness. Following James Bogen, there are at least three sense of

theory-ladenness in Kuhn: perceptual theory loading, semantic theory loading, and salience (Bogen 2017). Kuhn thinks that perceptual theory-ladenness means that how an observer perceives the world is, in part, determined by the theories that each observer adopts (Bogen 2017, section 4). Thus two observers considering the same phenomenon, may “see” that phenomenon differently, depending on the conceptual frameworks from which they start. Likewise, semantic theory-ladenness concerns the role theory plays in how we understand observational descriptions (Bogen 2017, section 4). Two different observers might, therefore, use the same language to report the same observation but mean quite different things. With salience, Kuhn worries that what a person counts as important in her theory will influence the data she collects so that two observers might collect different data from the same experiment (Bogen 2017, section 4).

Tal does not explicitly address these kinds of theory-ladenness or the degree to which they are relevant to other sorts of theory-ladenness because he is interested in a different theory-ladenness. He is concerned with clarifying the evidential role that measurement plays in science. Theory-ladenness with respect to the evidential role of measurement refers to the fact that scientific theory is required to develop the very measures that are then used to count as evidence for or against that theory (Tal 2017).

One reason we might worry about whether a measure is providing any evidence for an account is that we adopt a scientific account before we have been able to test it and we then evaluate newly developed measures based on the predictions of that account (Tal 2017, section 8.2). The measures are themselves a result of the very theory for which they are intended to provide evidence—this is the theory-ladenness that interests Tal. While Tal does not address Kuhn’s more general notions of theory-ladenness (that I have

mentioned above) he does consider Kuhn's account of whether measurement can play an evidential role in science. He acknowledges that Kuhn's argument is that "the function of measurement in the physical sciences is not to test the theory but to apply it with increasing scope and precision, and eventually to allow persistent anomalies to surface that would precipitate the next crisis and scientific revolution" (Tal 2017, section 8.2). However, Tal argues that Kuhn is not against measurement playing an evidential role in science, but is only arguing that measurement tests a theory by comparing it to an alternative theory as each attempts to account for anomalies (Tal 2017, 8.2). In concluding that at least Kuhn's account is not at odds with measurement playing an evidential role in scientific theory, Tal seems to think that Kuhn's account is not at odds with contemporary accounts, which, he notes, routinely accept that

theory-ladenness is a prerequisite for measurements to have any evidential power. Without some minimal substantive assumptions about the quantity being measured, such as its amenability to manipulation and its relations to other quantities, it would be impossible to interpret the indications of measuring instruments and hence impossible to ascertain the evidential relevance of those indications [...]. Moreover, contemporary authors emphasize that theoretical assumptions play crucial roles in correcting for measurement errors and evaluating measurement uncertainties. Indeed, physical measurement procedures become *more* accurate when the model underlying them is de-idealized, a process which involves increasing the theoretical richness of the model" (Tal 2017, section 8.2, author's emphasis).

The remainder of this chapter is focused on considering in detail how scientific theory informs measurement and *visa versa*, and how Tal's modeling account reconciles a variety of tensions and justifies metrology practices that might otherwise seem *ad hoc*.

II.1. Measuring Time: Atomic clocks and the Project of Developing Reliable Measures

Around 1600, Galileo Galilei is trying to describe the pendulum mathematically and is observing that the period and amplitude are independent. By 1657, Christiaan Huygens develops the first pendulum clock—the timekeeping mechanism that would measure time and coordinate human activities for nearly three hundred years (Edwardes 1977, 16 and 26).¹ Keeping time according to the motion of a pendulum may seem a straightforward means of measuring time. However, if we imagine ourselves as the metrologists looking at a swing pendulum, we find that we soon worry over whether our pendulum swings at constant rate and we begin to worry, as Huygens himself did, that it may, as it continues to swing, swing faster or slower than when it started. So we add a second pendulum to compare with the first but now it seems we have multiplied our concerns. Either the two pendulums match each other precisely or they do not. If they do not match then we obviously now must choose between the two or add another pendulum in an attempt to gain some sort of confirmation of one or the other of our two original pendulums. And so on we go, adding layers of pendulums by which to evaluate and calibrate our earlier pendulums. On the other hand, if the two starting pendulums *do* match one another, we still face the Poincaré like concern that we cannot be sure that the pendulum swings are neither uniformly slowing down nor speeding up—so our concern about the reliability of the swinging pendulum is unaddressed (Poincaré 1905, 49-51). After all, “two successive periods of a clock cannot be compared by placing them temporally side by side, that is why direct perception can’t verify whether they lasted equally long” (van Fraassen 2010, 130).

¹ There is a long discussion about who designed and built the first pendulum clock.

Huygens also shared these worries and, after analysis of the very high amplitude of early pendulum clocks, concluded that such clocks were not truly isochronous and that smaller amplitude was better (Edwardes 1977, 93). Accomplishing smaller amplitude, however, required extensive redesign of the early clocks. In pendulum clocks, as with the later cesium clocks, empirical, practical, and theoretical concerns are all important parts of the design of the clock. Thus is born our need for theories of measurement that address the epistemic concerns we have regarding the methods and modeling practices we use to keep time. Though we no longer rely on pendulum clocks, we now face these same sorts of difficulties in our use of atomic clocks. Both clocks share the further similarity that neither the pendulum nor the cesium atom ‘tells time’. While each, the pendulum and the cesium atom, are used to regulate their respective clocks, neither are measurement devices save in conjunction with the rest of their clocks.

In the first part of this section, I provide a tidy, although simplistic, explanation of atomic clocks. The second part begins to address the untidy realities of atomic clocks and the lack of agreement between data that exists between the clocks that metrologists use to maintain a standard time. In the third part of this section, I explain the intricate processes involved in arriving at a single, standard, time using these atomic clocks.

II.1.i. How cesium clocks work

The International Bureau of Weights and Measurements, BIPM, defines the second as “the duration of 9192631770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom” (BIPM 2006).² Metrologists currently use cesium fountain clocks to maintain standardized time.

² Why they define it so has a great deal to do with a long history of time keeping.

Fountain clocks maintain a standard second via frequency cycles in the cesium atom, which are determined by shifts in energy states.

Shifts in energy states occur when microwaves excite cesium atoms from one energy level to a higher energy level, or hyperfine state. In order to move an atom from one energy level to another, the atom is bombarded by electromagnetic radiation of a specific frequency. This bombardment reverses, or flips, the direction that the outer electron, within the atom, is spinning. When the electrons and protons are spinning in the same direction as each other, the atom is in a hyperfine state (Jones 2001, 136-139, 163-169).

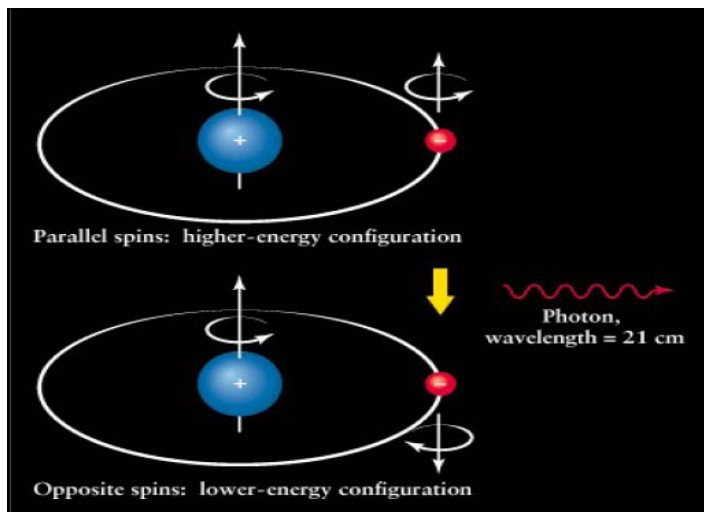


Figure 2.1. Energy Decay in an Atom.³

³The graph indicates the energy decay, or flipping, that occurs as an atom moves from a higher hyperfine state to a lower one. As it moves back towards this lower energy level it emits a photon. Note that this model depicts a hydrogen atom. The direction of spin, however, induces the same shifts in energy level regardless of the type of atom. <https://astronomylog.files.wordpress.com/2013/06/hyperfine.jpg>.

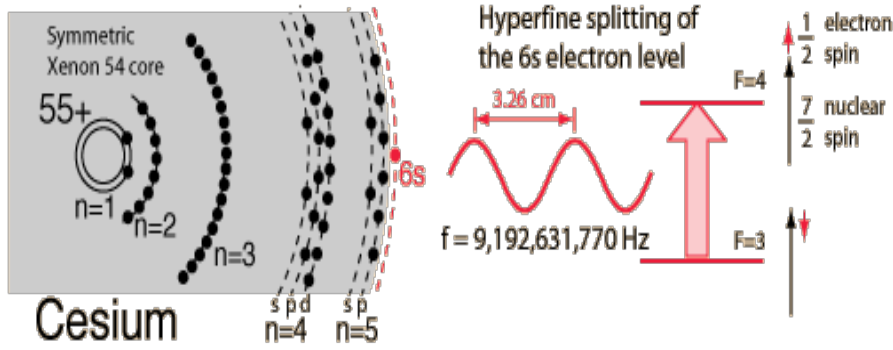
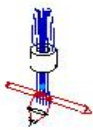


Figure 2.2. Hyperfine States of the Cesium Atom.⁴

Although there are several types of cesium clocks, currently the primary standard clocks are cesium fountain clocks:



Fountain Clock Layout

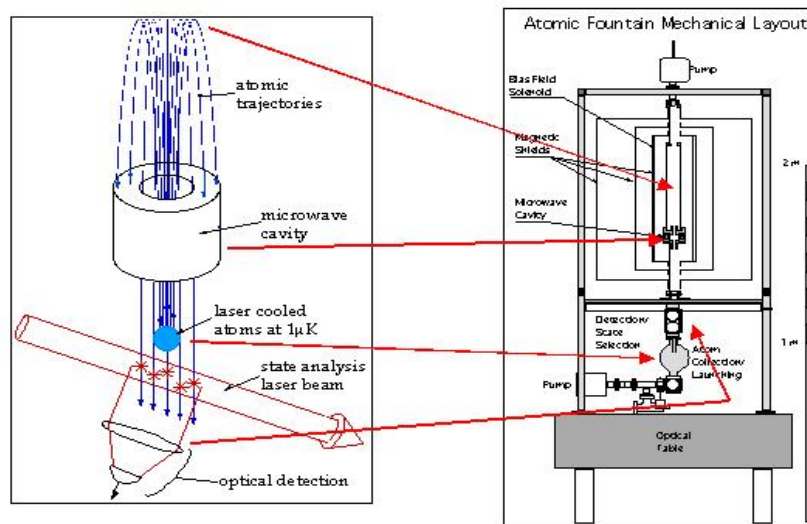


Figure 2.3. Cesium Fountain Clock⁵

⁴This graph provides a more detailed illustration of the hyperfine states in a cesium atom. It highlights the '6s' electron, which refers to the particular shell and sub-shell of the atom occupied by the electron. <http://hyperphysics.phy-astr.gsu.edu/hbase/images/csclock.gif>.

⁵<http://tycho.usno.navy.mil/clockdev/layout.jpg>

The BIPM definition of the second assumes cesium atoms are in a zero temperature state and that the frequency they respond to is exactly 9192631770 Hz (BIPM 2006). The atomic clock's work is to bring cesium atoms as near as possible to the ideal state where 9192631770 Hz is the transition frequency that moves them from one hyperfine state to the next. To that end, the fountain clock works by cooling cesium atoms to within a few nanokelvin of zero Kelvin degrees before transitioning the atoms to a hyperfine state (Jones 2001, 166-168). Cesium atoms are cooled to their ground state by tossing them upwards through the microwave cavity that emits a frequency to flip them into this lower state. As they then fall back down through the same cavity it emits another frequency to excite them into a higher energy state (Jones 2001, 166-168). During this trip up and back down, the atoms are also exposed, at various times, to other lasers and magnets, which are designed to cull out any atoms that have not properly transitioned to each energy state. As the atoms relax into a lower energy state, they emit photons that match the frequency used initially to excite the atom. Detectors in the clock then absorb the photons (Jones 2001, 45-50). These photons help adjust the clock to the frequency that will maximize the number of cesium atoms transitioning to a higher energy state. Once the maximum number of photons are emitted, we 'know' that we have reached the transition frequency of 9192631770 hertz (Jones 2001, 45-50). Once we find the right frequency, we count cycles until we hit 9192631770 cycles—the duration of a second.

The point is that we aim to 'tune' the clock to the 'target' frequency of 9192631770 Hz, a frequency we believe, based on theory, will maximize the reaction of cesium atoms. We 'turn the frequency dial,' so to speak, until it appears that we have maximized the reaction of our cesium atoms, which we judge based on the number of

photons they emit as they relax after being excited (See also Audoin and Guinot, 2001). Here, as with the pendulum clocks, the presumed regularity of the natural phenomenon is used to regulate the clock.

These fountain clocks, also known as primary standards, are not used to directly maintain our day-to-day time. Instead, primary standards are a collection of about a dozen clocks around the world that, out of necessity, run only part of the year.⁶ Their purpose is to calibrate secondary standards thereby ensuring that the standard length of the second does not drift. Secondary standards are a much larger group of clocks, around four hundred, around the world, that provide data continuously (Tal 2014, 5-6). The data from the primaries is averaged together in order to arrive at a standardized second. This average is then periodically checked against the primaries to ensure that the secondary atomic clocks are remaining within the accepted margin of error or uncertainty (Jones 2001, 72, 79-89). We will talk more about this process of averaging and creating the standard second and other issues in the next part of this section.

II.1.ii. Disagreement Between Standard Setting Clocks: A Lack of Data Agreement

Many of the difficulties of time measurement come in the gap between what our theories claim and predict and what our instruments actually produce. The models and instruments intended to implement our theories, instead of producing data that exactly matches and supports those theories, produce raw data that does not match the theoretical predictions about how the world works. It turns out, when we step a bit closer, that our

⁶Jones notes that each primary clock unique and built by hand. These clocks are largely experimental with their designers constantly trying to improve accuracy by refining and tweaking them. Because of their experimental nature, most of these primary clocks do not run continuously (Jones 2001, 72).

predicted results for the cesium atom are based on ideal states in which cesium atoms do not actually exist.

The discrepancy between reality and theory is not isolated to measurements of time; rather it is prevalent throughout science. As Thomas Kuhn notes,

Almost always the application of a physical theory involves some approximation (in fact, the plane is *not* “frictionless,” the vacuum is *not* “perfect,” the atoms are *not* “unaffected by collisions”, and the theory is not therefore expected to yield quite precise results. Or the construction of the instrument may involve approximations (e.g., the “linearity” of vacuum tube characteristics) that cast doubt upon the significance of the last decimal place that can be unambiguously read from their dial. Or it may simply be recognized that, for reasons not clearly understood, the theory whose results have been tabulated or the instrument used in measurement provides only estimates. For one of these reasons or another, physical scientists rarely expect agreement quite within instrumental limits. In fact, they often distrust it when they see it (Kuhn 1977, 165. Author’s emphases).

Metrologist, like most scientists, must anticipate and calculate for the imperfect conditions of reality even as they recognize that their results will lack a certain degree of ideal exactness. As already noted, the official definition of the second assumes ideal states. It assumes that the cesium atom is at a perfect zero degrees Kelvin, is existing in a gravity free state, is perfectly isolated from other kinds of atoms, is only responding to a precise frequency of 9192631770 Hz, and on the list of idealizations goes. But none of these ideal states are present in actual cesium clocks.

Instead, many non-ideal factors, including other environmental factors as well as the quality of the model used for measurement, contribute to the inaccuracy of measurement. Cesium atoms respond to an exact frequency of 9192631770, but only in theory. In reality, the transition frequency of cesium atoms reaches the single value of 9192631770 Hz “only if averaged over an infinite duration, due to so-called random fluctuations” (Tal 2011, 1098). In reality, cesium clocks cycle faster and slower, with

more and fewer cycles, than the ideal rate. Ideally, cesium atoms are the only atoms in the chamber but, in reality, there are often other kinds of atoms feeding information into the photon detector, thereby skewing the frequency. Gravity, movement of the earth, and location on the earth—each affects the behavior of cesium atoms, in turn affecting the data (Tal 2011, 1088-1089; Audoin and Guinot 2001). However, since scientists expect these discrepancies, they also *try* to calculate for non-ideal conditions: they figure for a certain range of rates in cesium cycles; they figure for certain levels of impurity in their atoms; and they figure for non-zero temperature of the atoms.

Scientists develop models of physical systems such as these atomic clocks, and these models are aimed at bridging the gap between theory and reality by accounting for non-ideal conditions. The more accurate scientists are in developing a model the more reliable the measurement data resulting from that model (Tal 2011, 1088-1089). However, the quality of the models we use to develop a clock, as well as the theories informing these models and the instrument itself, affect the accuracy of the data. Section three will look more closely at the idea of models and modeling, so for now we skip a proper discussion of it.

As metrologists account for the non-ideal realities facing each atomic clock, their accounting enables them to assign a somewhat specific uncertainty value. Assigned uncertainties are summed to provide the total uncertainty margin, or uncertainty budget, for the data collected from that particular clock (Audoin and Guinot 2001, 240-254; and Tal 2011, 1090). Uncertainty budgets allow metrologists to predict the future data output of these clocks to within the calculated range of uncertainty. When a clock's data regularly falls outside of these margins, metrologists call the clock unstable and it is

given less influence when it comes time to average the data from all the clocks into a unified second. Still, even with all these attempts to calculate for uncertainty, additional measures, such as leap seconds where metrologist coordinate the skipping of a second in order to help correct the inevitable drifts of their atomic clocks, are both needed and employed (Jones 2001, 108-113).

The result of studying all these uncertainties is the realization that raw data rarely says what we want it to say. Moreover, terms such as “reliability” and “accuracy” may not mean what we want them to mean. If we impose regularity on nature, as some of these metrological practices do, in what sense can we talk about the accuracy of our measurements or the reliability of them? It appears that what we once took as “getting the facts right” is actually a good deal more like “making the facts up”. That we make facts, is not to say that we can assert anything we like, but is rather to recognize that our facts are more like agreements forged under the constraints of various considerations, such as empirical, physical, social, theoretical, and so on. Terms like “accuracy”, “stability”, and “reliability” seem increasingly problematic because they require that we pay closer attention to the constraints that guide our development and use of such terms. A natural question to follow this discovery is: how well grounded are our claims about the world? The most reliable models produce data that requires more tweaking, manipulating, and altering than we would like. Even if this process of arriving at standard time is the norm for metrologists, the idea of altering and manipulating data sounds unscientific. So how do we justify the manipulation of data and the *ad hoc* bootstrapping of our science?

II.1.iii. Standardizing Non-Standard, Standard Clocks: Calculating and Creating Data Agreement

The problem of arriving at a set of clocks that demarcate a perfectly regular second is still before us. We cannot base our standard of a clock on just one clock because even clocks that agree to a very high level of precision do eventually drift away from one another. Clocks and seconds can potentially drift further from each other, running faster or slower than one another (Tal 2016, 10-11). In order to standardize world time, data from each primary clock is weighted and then averaged together to provide a standard for the second against which the primary clocks are then measured in future. For example, ten primary clocks are used to set our standard time but their daily seconds are not identical. Instead, for each month, an average of these clocks' reports on the length of the second are averaged for the month and then this average is taken as a standard for the following month. This standard for the following month is then used to reassess the clocks themselves and determine their reliability and stability. Should a clock run too fast or too slow—defined as falling outside the margins of error which are set by what other clocks say, on average—it is removed so that its data no longer averages into the total thereby preventing it from improperly affecting the monthly average. This sort of solution, however, immediately raises other concerns, such as the possibility that a few clocks might unduly affect the monthly average over time as their data carries more weight in the calculations, thus slowly skewing the standard time. To help avoid that problem, each primary clock is weighted according to the reliability with which its actual cycles match its predicted cycles. The predicted cycles are based on standard length of a second that

was taken from the average of the primary standard atomic clocks from the previous month.

To further limit any one clocks' influence, no clock can be assigned an influencing weight of more than .7 in the averaging calculations for creating the standard each month. This weight is based on how consistently and closely the clock matches the predicted second of each month. Additionally, clocks are assigned individual uncertainty margins that are distinct from, though added into, the collective uncertainty margins. Individual uncertainty margins speak to the reliability of each clock in performing consistent with itself. Clocks that consistently do not perform within their uncertainty budgets are not assigned any weight. Before a clock is used as a standard, it is first given a calibration test for several months, during which time its data is not averaged into the total of each month. This test time allows metrologists to evaluate the reliability of the new clock and assign it an appropriate influencing weight (Tal 2016, 8). Moreover, a clock's assigned weight can change over time as its performance improves or deteriorates.

Perhaps odd to some, "The Second", as such does not exist anywhere. The standard second is constructed; it is the outcome of averaging many individual instruments' seconds together to create a single value. There is no one clock, no single process that gives us the second. Instead, the second is constructed from many individual instantiations, all differing from one another.

We hope to find agreement between various processes and then to call this agreement 'regularity'. Instead, we look at a process and find that it does not agree with other periodic processes, or with other 'instances' of the same type of process (as

happens when we compare the decays of some cesium atoms to the decays of other cesium atoms). Just as regularity does not imply an objective reality, so too, stability does not imply something like ‘in sync with an absolute standard.’ Instead, when we talk about the stability of an atomic clock, we mean something like, that it has a high degree of agreement, that is, reliability or repeatability, between different cesium clocks, in contrast to other kinds of clocks, such as water clocks (Tal 2016).⁷

And so, in the history of keeping time, we find a complicated story of our attempt to arrive at regularity and stability in our clocks in the face of not only theoretical and empirical difficulties, but also of social and political difficulties. Possibly just as interesting to our discussion are the social and political reasons for why and the cesium atom serves as our means of measuring the second.

The cesium atom defines the second, in part, because it is more stable than alternative clocks and, in part, because it is the duration that most closely matched the definition of a second that was already given by the more established Ephemeris Time (Jones 2001, 112). While the cesium clock was emerging as a reliable and efficient mechanism for time-keeping, the International Astronomic Union was in the middle of a transition from Universal Time (UT), based on the mean solar day or 86400 seconds per day, to Ephemeris Time (ET), based on the subdivision of the tropic year 1900 (Jones 2001, 17-19 and 55-59; Audoin and Guinot 2001, 38-64). The tropic year is measured from one spring equinox to the next. UT turned out a less reliable measure because the mean solar day is not regular—it fluctuates in length. ET runs into a slightly different difficulty. Because ET was originally calculated by the movement of the moon relative to the background stars, one of the challenges becomes taking the measurement quickly

⁷ More on this in section two.

enough to be accurate. The Moon's relatively quick movement makes its position relative to the stars hard to measure. Moreover, the moon's brightness in comparison to the stars also makes getting a good picture for measurement of the moon, in relation to the stars, difficult. But by the time the cesium clock was thoroughly established as more efficient and reliable than Ephemeris Time, Ephemeris Time was itself established as the standard of the second. Despite the clear advantages of atomic time-keeping, astronomers, the traditional time-keepers, were reluctant to relinquish their control of time-keeping to physicists (Jones 2001, 53). To ease the transition, the atomic second was defined according to the duration of the Ephemeris second. The cesium atom with its 9192631770 cycles turned out the most accurate measure of the ET second (Jones 2001, 55-59).

In a sense, the use of Ephemeris Time to set the standard of a second was an accident of history. The odd arbitrariness that we find in this history of standardizing time is the blatant *declaration* of time as regular despite the obvious irregularity in our measurements of it. The habitual move from one irregular means of measurement to the next, all while maintaining the claim of regularity, is at the very least interesting. It seems to reveal a consistent willingness, on the part of metrologists, to accept constructed regularity despite the obvious irregularity in nature. We will turn to this point in the following section.

II.2. Social and Data Driven Measurement: Real vs. Constructed

What do we say about this process? It appears stable, in that we have a working, regular coordinated universal time, but how do we explain the stability? Stability is about producing consistent long-term outcomes, or, as Eran Tal argues, stability encompasses

both repeatability and reproducibility over time or across particulars (Tal 2016, 23). We judge the stability of a system by how frequently we must intervene, change, or correct the process. When relatively few and minor adjustments are needed, we have attained greater stability than when larger and frequent corrections are needed. But the process by which we hobble our way towards stability, such as leap seconds and declared regularity, do not appear legitimate, so how do we justify them? Two explanations are the Realist and Constructive accounts. On the Realist account, scientists select and attempt to define pre-existing regularities in the natural world. On the Constructivist account, regularities are socially constructed. As this section will show, although each account captures something plausible about stability, they also both fall well short of providing satisfying answers to our questions about stability and, even more apparently, about the legitimacy of the means used to arrive at our measurement results.

II.2.i. Realist Account: Socially developed definitions of pre-existing regularities

On a realist's account of measurement, scientists are about the project of constructing definitions of regularity that correspond to the pre-existing regularities in nature. Realists emphasize that there is an objective property that a process might have, or fail to have, and that objective property is regularity; our task as metrologists is to go into the world and find a process that has this property, and use *that* process to define a stable unit of time. Once a definition is developed, measurement becomes about describing the mind-independent, regularities of nature (Tal 2016, 14-15). Pre-existing regularities are the standard against which definitions are evaluated and then either kept or abandoned in favor of more accurate definitions. For realists, whatever artificial construction or social influence occurs in science, it occurs at the level of defining. Creating definitions and

arriving at wide agreement on definitions is where the social components, such as international relations, politics, and so on play a role. Once a definition is given, the work of construction is finished and either the definition fits natural occurrences or it does not. Determining the fit, moreover, is the simple process of observation, devoid of interpretive choice or theoretical work (Tal 2016, 15).

Initially the choice of definition is entirely open. However, that choice is quickly limited as scientists bring those mind-independent regularities to bear on the chosen definitions. With respect to time,

From a [realist] point of view, the main task facing metrologists is that of detecting which of the hundreds of atomic clocks used to standardize time ‘tick’ at a more stable rate relative to the defined cesium frequency. If the algorithmic maneuvers employed in the calculation of UTC [Coordinated Universal Time] serve any epistemic purpose, it is to detect these stable clocks. A [realist], in other words, would view UTC as an indicator for regularities in the frequencies of clocks, regularities that may be described more or less simply but are themselves independent of human choice. The reproducibility of contemporary timekeeping would accordingly be explained by the reliability with which the UTC algorithm detects those underlying regularities (Tal 2016, 16).⁸

On the realist view, long-term stability is natural, even expected, because the regularities exist quite apart from any human construction; however, short-term stability becomes the focal problem for the realist view. The realist account fails to explain the short-term stability of standardized time—that is the week-to-week and month-to-month consistency of data outcomes that metrology maintains. Since no two clocks agree with each other exactly, to create a single standard time, metrologists weight various clocks, integrate the discrepancies, or simply eliminate clocks that consistently yield data outside the allowed

⁸ Note that Eran Tal, for reasons particular to work in measurement practices, in his papers calls the same set of people, whom I refer to as ‘realists’, ‘conventionalists’ (I expand on this substitution in the next footnote). For the sake of consistency in this dissertation, I have inserted ‘realist’ where he uses ‘conventionalist.’

margin of uncertainty. This seemingly *ad hoc* process of standardization is not something that the realist account of measurement can justify (Tal 2016, 18).⁹ On the realist view, mind-independent regularities are simply measured—the clocks agree or do not agree. If they do not agree, we go back to the drawing board to develop a better definition of the second. What metrologists certainly do not do, on a realist account, is manipulate and even entirely eliminate data in order to create a single universal standard of time. But the realist account is wrong. Though the realist might wish for a tidy process that is free of manipulation, manipulating data is exactly what metrologists do. And so the job of ensuring short-term stability exists and appears quite necessary to maintaining a standard of time. The realist account struggles to explain this practice.

II.2.ii. Constructive Account: Socially constructing regularity

Constructivists look at the process of time keeping and see a different reality and tell a different story. Constructivists, for the purpose of this paper, are those philosophers who understand time keeping as “a matter of constructing regularities from otherwise irregular instruments and human practices” (Tal 2016, 18).¹⁰ Instead of viewing the regulations and prescribed processes of the BIPM as peripheral corrective measures to an otherwise objective regularity, constructivists see the BIPM’s work as central to developing and maintaining Coordinated Universal Time or UTC. Only after the highly social procedures are applied to raw data does the data gain uniformity and regularity. While

⁹ The brand of realists, or in Tal’s words conventionalists, that Tal has in mind for this view are Ernst Mach (1919), Henri Poincaré (1958), Hans Reichenbach (1958), Rudolph Carnap (1995). The reduction of these figures to realists is not quite fair as some, like Poincaré, fall somewhere between a realist and anti-realist (Heinzmann and Stump 2017), and others, like Mach, are understood as anti-realist about certain things, such as unobservable entities (Poijman 2011). While Tal preserves this finer point by calling them conventionalists, I have opted to call them realists to make clearer the realist aspects of their views that Tal is considering and that counter a constructivist account of measurement.

¹⁰In particular, the constructivist that Tal considers are Bruno Latour (1987) and Simon Schaffer (1992).

realists also recognize the need for corrections, they understand their corrections as attempts to get *at* underlying regularity in nature. Constructivists not only think that such an underlying regularity is non-existent, but also explain the seeming stability of time keeping as a result of social, economic, and scientific interests in uniformity. Because it is of value to us to have a universal standard time, we set about creating one. For example, we might care, for political reasons, that a variety of countries participate in time-keeping, so we make little compromises to the benefit of each country, while still using regulated procedures that follow a step-by-step method until those countries have entered UTC. Thus UTC is an expanding ideal, slowly encompassing more countries as more countries opt to join the project.

UTC is not an actual natural phenomenon that we tap into or measure; it begins to look like such only after we develop committees, make *ad hoc* corrections to or eliminations of non-conforming data or clocks, and prescribe procedures for turning non-regular data into our regular, stable, clocks (Tal 2016, 20). When constructivists look at the process of time keeping they do not see a simple project of science or the idealized study of nature. Instead, as constructivists see it,

...atomic clocks agree about the time because standardization bureaus maintain an international bureaucratic effort to harness those clocks into synchronicity. To use Latour's language, the stability of the network of clocks depends on an ongoing flux of 'paper forms' issued by a network of 'calculation centers'. When we look for the sources of regularity by which these forms are circulated we do not find universal laws of nature but international treaties, trade agreements and protocols of meeting among clock manufactures, theoretical physicists, astronomers and telecommunications engineers. Without the resources continuously poured into the metrological enterprise, atomic clocks would not be able to tell the same time for very long. From a constructivist perspective, the algorithm that produces UTC is a particularly efficient mechanism for generating consensus among metrologists (Tal 2016, 19).

However, while the constructivist account can explain short-term stability, it struggles to explain long-term stability. If UTC is merely a constructed regularity and a socially jury-rigged stability then why do we find that, in the course of maintaining stability over the long-term, only minor interventions are ever needed rather more drastic interventions? Our standard second remains remarkably, well...standard in duration, even after we have been at this measurement practice for years. Part of what defines our time keeping process as stable is the fact that it requires only minor and occasional corrections. On a constructivist account, we would expect to see large and frequent corrections in order to maintain regularity. Instead of quickly reverting to irregularity, our clocks, when left alone for a time, maintain their regularity, which is one of the reasons we find time keeping a useful project. Were it so unstable as to require constant monitoring and tweaking, we would likely find it a useless tool (Tal 2016, 20-21). We might still think that perhaps this long-term stability is artificial if we were able to reproduce it with any medium we chose. However, stability has proven far more difficult to maintain with other mediums, for example organic mediums such as the human pulse.¹¹ And so just as short-term stability remains a thorn in the sides of realists, long-term stability becomes the equally entrenched thorn in the sides of constructionists.

II.3. Tal's Solution: Time as a Humanly Developed Measurement Tool

Eran Tal answers the measurement problem by arguing that when we re-visualize stability we come to an account of measurement that integrates both the realist and constructive accounts of regularity into a model-based account of time-keeping. Moving to a model-based account of measuring time leaves space to validate certain versions of

¹¹ Tal notes attempts at time keeping based off of the Human pulse. However, atomic based attempts remain far more stable than organic based attempts (Tal 2016, 21).

both social regularity and objective regularity accounts. However, with the model-based account of the second comes the question of whether or not time is real, and in what sense it is real. While Tal refrains from metaphysical commitment in his work, I draw on his work expressly to examine the possible implications it has for metaphysical commitments.

II.3.i. Re-visualizing stability

Realist and Constructive accounts of how we arrive at measurement stability, as we have seen, are at odds. While the realist approach accounts for stability through “the empirical regularities exhibited by the behavior of measurement standards,” the constructive, or social, approach accounts for stability through “the social coordination of policies for regulating and interpreting behaviour of measurement standards” (Tal 2016, 12). Since both accounts provide necessary explanations for stability and yet are also insufficient without one another, Tal suggests that the solution is to re-conceive the notion of stability. In doing so, it becomes apparent that these two positions are not mutually exclusive, but, rather, are inseparably amalgamated components of a satisfactory account.

Stability, traditionally, is about repeatability and reproducibility. However, according to Tal, neither the realist nor the constructive accounts address the question of how measurement outcomes are judged comparable to each other or what agreement between outcome measurements means. These issues are left unaddressed by both sides because both sides fail to recognize that stability is not something that exists without theory and modeling assumptions. Stability is itself defined by scientists. Therefore, Tal argues that we should recognize that stability “(both over time and across particulars) is a model-based notion. Which object or process counts as stable depends on the theoretical

and statistical assumptions under which that object or process is modeled” (Tal 2016, 22-23). The very concept of stability is, Tal argues, a theoretical concept, which in turn is informed by theoretically chosen and defined data.

Theory and modeling determine what, and in what way, data counts as stable. Instead of thinking of stability as being about regularity in measurement *indications* (i.e. the raw data collected), stability is properly understood as being about measurement outcomes. In turn, measurement outcomes are a result of both the raw data and the background knowledge used to understand that data (Tal 2016, 24-25). Staring at charts of numbers, lines, and dots, is unhelpful, unless one knows how to interpret those indications. Interpretive knowledge is gained through understanding things like modeling assumptions, likely errors in data, the appropriate corrections, the assumed explanations, and the theories that produce these models. The theories and the modeling assumptions, from which scientists operate, define what counts as stable; they define what counts as regular and reliable.

Stability in instruments thus becomes a relative property, “relative to some set of modeling assumptions” about the very instruments we deem stable (Tal 2016, 25). We produce notions like reliability, regularity, and stability as we make modeling assumptions and interpret data. Once it is clear that stability itself is a produced outcome, and not solely some preexisting occurrence in the observable world, an amalgamation of realist and constructivist theories appears less strange.

II.3.ii. Both Together: a Realist and Constructive Account of Regularity

So how do we take a view that sees regularity as a defined concept matched to objective realities and make it compatible with a view that sees all regularities as a result of

manipulation of raw data? Tal suggests that a non-literal interpretation of both the realists and the constructivist's position is both more useful and more charitable. Each view captures an essential component to understanding the science of measurement.

Constructivists have rightly understood the human component in science. Scientific theories are based on human idealizations and social expectations. Often, we initially pursue answers to problems like the geometric shape of earth, cancer, nuclear fusion, and so on, for social reasons. We find keeping time helpful in our lives for a variety of reasons ranging from agricultural to social to political to scientific. In each use we make of time, we find ourselves hoping for certain things from our time-keeping devices—certain levels of precision or regularity, depending on the particular activity in which we are using our time-keeping device. We develop our ideals, in part, based on our needs—that is, we imagine a timepiece that keeps time perfectly, in part because we have a wide range of uses that we could make of such an instrument (e.g. the theoretical to practical, the scientific to social uses of such a timepiece). So we have an idea of the perfect timekeeper, but this idea does not appear to exist in nature. We cannot find the atom that is perfectly regular and stable. We look, and constantly find that we are disappointed by nature—so we push, squeeze, and squish nature to fit our purposes and needs. Humans play an integral part in fueling theory and informing idealized definitions, through what we think and want. Not all the human influences involved in our scientific practices matter to our conversation. After all, human aspiration has inspired some of our best scientific results (such as flying and walking on the moon). Rather, the human influence that is interesting and that will trouble realists is the sort that leaves our resulting science not entirely objective. It is where our core scientific theories

and outcomes are shaped and influenced by humans and to unexpected degrees that will bother realists. Reproducibility, regularity, and stability are notions motivated by human expectation and in part defined by human choice. In this sense, the constructivists are right about measurement: idealized theory is socially constructed and informed on many levels. The explanations and motivations of scientific projects are inescapably constructed.

But Tal claims that the realists are also right: measurement is not solely a matter of construction. Rather, the empirical world resists scientists and, in doing so, excites revelation and revolution. Realists argue that human beings write definitions (e.g. of regularity or stability) and from there merely attempt to match their definitions to natural occurrences. Where none is found, they revise their definitions and return to the search for an empirical match. As scientists take their theories and hold them up against the empirical world, expectations and predictions of how the empirical world will act fail, revealing theoretical shortcomings and requiring further explanatory work. This bumping up against the empirical world happens, for example, when scientists discover that two standard clocks fail to match each other. Once the unexpected divergence between these two clocks is seen, metrologists have to revisit their theories about the world in order to explain why their prediction that these clocks would match failed. Metrologists, however, do not simply redefine the second, synchrony, or regularity as realists might prescribe. Rather, metrologists often tinker with their data, excluding some of it or altering it until they have managed a body of data that, with just the right interpretive lens, supports the outcomes they draw from it. As we have seen, a literal interpretation of the realist position suggests that they cannot quite justify the need to

tamper with data in order to make it fit expectations. This more charitable read, however, allows space for their account to integrate more constructivist explanations.

Tal argues that each position is, in its own way, right. Measurement *is* socially informed and it *is* empirically informed. Human construction and empirical occurrence create a dialectic, forming and informing each other. As long as we do not insist on rigid, literal, interpretations of constructivists or realists, we can accept the crucial element that each view contributes to an accurate picture of the project of scientific measurement. Up to this point, however, the nitty gritty of how this process takes place—how this dialectic of social and empirical elements occurs—is unaddressed. Tal argues that through a model-based account of measurement, which draws on both the constructive and realist accounts, we can see, on the one hand, the details of how this process works, and on the other hand, the necessity for and the inseparability of these two components.

II.3.iii. A model based notion of time

Tal's account joins a larger trend, as Martin King observes, where the “focus in the literature on scientific explanation has shifted in recent years towards model-based approaches” (King 2016, 2761).¹² Since stability is an issue that has proved so troublesome for realists and constructivists alike, Tal begins an explanation of his model-based account with five main tenets that create a working account of both stability and the modeling process:

1. Stability (both over time and across particulars) is a model-based notion. Which object or process counts as stable depends on the theoretical and statistical assumptions under which that object or process is modeled (Tal 2016, 22).

¹² For additional examples of model-based accounts see Alisa Bokulich (2008, 2011), King (2016), Robert Batterman and Collin Rice (2014).

Essential to our measurement theory must be the understanding that the notion of stability itself is to some degree bound to our starting assumptions. Rather than naïvely assuming that like instruments will produce like indications, as both the constructivists and realists are prone to do, we need to embrace the reality that theoretical and statistical assumptions have important effects on not only our measurement outcomes but also on notions like stability. What stability means and the question of whether we have achieved it in any given measurement project is inevitably tied to things like our starting assumptions (about physical realities, ideal conditions, etc.), the instruments that we employ, and the calculations that we make to bring ideal theories to bear on non-ideal realities (Tal 2016, 23). To properly understand the process of measurement it is essential that we grasp that a

model of a measuring system is an abstract and idealized representation of the apparatus, the objects being measured and the elements in the environment (including, in some cases, human operators). Models of this sort are necessary preconditions for grounding inferences from indications to outcomes (Tal 2016, 23).

Therefore, Tal argues, when we ask about whether a measuring instrument is stable, we must recognize that the answer is always relative to the set of modeling assumptions involved in developing the instrument itself.

2. To standardize a quantity-concept is to regulate its use in a manner that allows certain exemplary particulars (i.e. measurement standards) to be modeled as highly stable (Tal 2016, 22).

Lest it appear that Tal's account is more sympathetic to a constructivist view, experience quickly reminds us that a notion like stability, while reliant on starting assumptions, is also restricted by empirical data. We begin with our idealized notions, but must quickly qualify and further define our notions so that we can use them in our accounts of

empirical phenomenon. We de-idealize by accounting for non-ideal circumstances such as the effects that various physical factors (such as gravity, altitude, temperature, and so on) might have on our outcomes. The aim is to sufficiently account for the differences that will show up between the actual outcomes and the idealized outcomes we had originally predicted. After all, as Tal points out, since we cannot isolate or place a cesium atom in precisely the conditions required by our ideal models, we must de-idealize our models until they are able to account for the realities of the concrete particulars.

We require further definitions and de-idealized models to guide us in discerning which empirical outcomes approximately realize our ideal models (Tal 2016, 24). The process of de-idealizing our ideal models or theories requires layers of models that range from fairly idealized models of our theories to increasingly de-idealized models. Because of the empirical restrictions on our instruments, we find ourselves returning again to develop more fine-grained models that will predict and calculate acceptable margins of error, calculating again and again the empirical realities that will effect and alter our outcomes. Through the modeling process, we coordinate the empirical world to our theoretical concepts. However, unlike the realist account that merely matches concepts directly with concrete particulars or processes, Tal's model-based coordination

..consists in the specification of a hierarchy among parameters in different models. In our case, the hierarchy links a parameter (terrestrial time) in a highly abstract and simplified theoretical model of the earth's space-time to a parameter (UTC) in a less abstract, theoretical-statistical model of certain atomic clocks. UTC is in turn coordinated to a myriad of parameters (UTC(k)) representing local approximations of UTC based on even more detailed, lower-level models constructed at national laboratories. Finally these local approximations of UTC are coordinated to measurement outcomes associated with individual atomic clocks (Tal 2016, 27).

And so we arrive at our actualized time—not without constraint by empirical realities, but also not through a naïve, simplistic matching of our idealized definitions with perfectly, pre-existing empirical regularities.

3. Metrologists are to some extent free to regulate the use of a quantity concept, not only through acts of definition, but also through choices of exemplary particulars and the assumptions under which those exemplary particulars are modeled (Tal 2016, 23).

By this point, it should be fairly clear then, that metrologists gain some freedom in effecting outcomes, since outcomes are based on one's interpretation and choices as one develops increasingly de-idealized models. There are many decisions that metrologists need to make and with each answer comes a freedom to effect the outcomes; decisions such as which parameters we will use to define our outcomes, how wide a margin of error will we permit, which actualizations of the second are acceptable, which imperfections will we aim to eliminate and which will we merely calculate into our margins of error, and so on the list goes. Thus, things like seemingly *ad hoc* operations and solutions aimed at eliminating discrepancies in the outputs of data are justified inasmuch as they are derived from de-idealizing models. And so we are reminded yet again that through the existence of so many choices comes yet another inescapable reliance on human preferences and decision-making, thereby further entwining our dream of a perfectly independent empirical reality, time, with the imperfect construction of time. Quite naturally, we now arrive at tenet four:

4. Success in stabilizing measurement standards cannot be explained by reduction to either natural or socio-historical factors; instead, stability results from the iterative entanglement of these factors in the process of standardization (Tal 2016, 23).

Models then play both a descriptive and prescriptive role in our work on measurement: “like other scientific models, they have a representational and descriptive function, i.e. explaining and predicting the behaviors of measuring systems” and they also “fulfill a prescriptive function, i.e. they exemplify how certain measuring systems should be described in terms of quantity-concept and hereby help regulate the use of that concept” (Tal 2016, 28). Instead of judging the accuracy of our models based on the frequency as given by the cesium clock, we judge the accuracy of the frequency based on our models (Tal 2016, 28). Thus, on the one hand we pick certain standards, like UTC, because it maintains short-term stability, not because it maps onto pre-existing regularities, as realists argued. On the other hand, we pick concrete particulars, like cesium atoms, because their use insures the sort of long-term stability that a rigid, constructivist account cannot explain.

Still, where the lines between our socially informed influences and our purely empirical influences fall is not clear, in part, because a metrologist’s freedom of choice is further limited by the larger webs within which our notions of terrestrial time are embedded.¹³ Theories like general relativity and quantum mechanics, to name a few, create a complex web that we already accept and which inform and constrict future theories. Whatever we say about time, however we develop clocks and measurement standards, we must say and develop things that remain coherent in our wider web of theories. So we arrive at a complex dialectic between the limitations imposed by society and the limitations of empirical reality. Sometimes we find our models evaluated from a top down view and sometimes from a bottom up view, and yet without either approach restricting and informing the other, we would not arrive at a sufficiently complex model,

¹³See also Pierre Duhem (1998) and W. V. Quine (1998).

or explanation for that matter, of actual standard time. As we blend society and nature, we arrive at our approximation of the ideal, universal, standard time.

5. Standardization projects produce genuine empirical knowledge; this knowledge is nonetheless mediated by background theoretical and statistical assumptions and shaped by social and pragmatic constraints (Tal 2016, 23).

By understanding our time-keeping methods in this modeling way, Tal argues that we can epistemically justify both the process and the results. We now have an account of why our seemingly ad hoc moves and switches in perspective, either from theory informing data or data informing theory, are justified: the project of time-keeping is inherently a dialectic between nature and society. If we want a sufficiently strong account, we cannot explain the process as entirely socially driven or entirely driven by nature. Instead, our measurement results are informed by nature and yet their correctness is relative to the correctness of the broader theoretical webs and assumptions in which we situate and form them (Tal 2016, 30-31). We arrive at empirical knowledge, but not in the pristine and socially untainted manner we often imagine.

II.4. Looking forward—Implications for Metaphysical Accounts of Time?

While Tal offers an epistemic solution to how we view stability and the means by which we arrive at consensus in our data, he consciously refrains from providing a metaphysical account. Nevertheless, his account is suggestive with respect to the metaphysical account of time. His embrace of constructivism threatens realist metaphysical accounts of time by suggesting that time is not entirely a mind-independent reality. Alternately, his embrace of real world regularity blocks any entirely constructivist metaphysical account of time as well. Tal's project was to justify our current practices of time-keeping and provide an epistemological account of the measurement of time that re-inspires

confidence in our seemingly doubtful scientific practices. To reestablish our confidence, Tal argued that what makes our practices seem questionable is that we are viewing them from the wrong vantage point. Once we realize that measuring time is a project constrained by both humans and nature, we can move forward with greater confidence in our practices.

Tal's work, however, leaves us with the metaphysical question of what exists because of humans and what exists independently of humans? If time is somehow dependent on humans—then is it real? If it is somehow real, then is it also constructed? I aim to provide a metaphysical account that parallels Tal's epistemic account by suggesting that time is a means of measuring a real thing, change. Understanding time in this way is not only reaffirmed by our measurement practices, but also will make better sense out of our discussions of time both in physics and metaphysics.

An initial response that one might have to this time-keeping literature is to say that the BIPM definition of the second is counterfactual, concerning idealized cesium clocks, which are approximated by messy actual ones.¹⁴ While we might not be able to escape the non-ideal confines of the measurement process, that fact hardly requires the conclusion that the world is itself messy and non-ideal. On this response, our ideal (say of the cesium clock) is what we would find if the world were such that we could skip past the messy constraints that we encounter as we try to measure the actual world. This sort of response might be rooted in a commitment to realism that we defend by an inference to the best explanation (IBE).

Advocates of IBE might argue that an underlining reality that supports our ideals is a better explanation of why our measures are at all successful, even if imperfectly

¹⁴Thank you to Alexander Pruss for suggesting this response.

successful. But IBE is far from inevitable or uncontroversial. Bas van Fraassen replies to these sorts of defenses of IBE by arguing that such inferences rely on the options from which we are choosing. It may be that we have a lot of wrong theories about the way the world is, in which case we find ourselves choosing a theory that is merely “the best of a bad lot” (van Fraassen 1980, 143). So then, the obligation to believe one of a given set of theories holds only if I am sure that the true account of the world is included in that set (Okasha 2000, 694). Nancy Cartwright has also responded to IBE by arguing that idealization—and she is dealing specifically with laws of physics—should not be taken as an indication of an underlying truth or fact about reality, but instead should be taken only as a truth about things in the models to which the idealizations belong (Cartwright 2002, 4). It is not clear what, if anything, idealizations tell us about reality and she argues further that we ought to understand them as false and not mistake their explanatory power as an indication of their having captured some underlying truth about the world.

While I find these sorts of arguments forceful, the account of time that I am presenting here is not intended to show that one cannot be a realist about time and appeal to IBE as a way of explaining the messy construction work involved in measuring time. However, it is also the case that a realist response does not hold a preferred place for offering the best explanation. Where realists may want to point to the success of our measurement as confirmation of some underlying reality, it is as good an explanation to say that the success of our measures is due to our hard work to forge success. Realists may want to counter with the question, what is it that makes success possible? To this question and for the remainder of this dissertation, I offer a semi-realist response that while the world must be such that it enables our successful measuring of it, this

admittance says nothing about the correct metaphysical account of time. While time may not be the underlying reality that makes success possible, change could be the underlying reality that explains both our success in measurement as well as our need to construct certain measures, such as time. Far from denying the reality of change, I endorse it and our ability to measure it in numerous ways through constructing many kinds of measures (from temperature to time to weight, and so on) on which we more or less manage to agree.

Chapter III: An Account of Change

In this chapter, I explore the notion of change from the Aristotelian tradition. The aim is to show that at least some accounts of change fit with the account of time I am suggesting, rather than to attempt to argue for a particular account of change. Although I start with Aristotle and provide some exposition on the scholarly debates surrounding interpretations of Aristotle, I am concerned less with settling the debates than I am with developing a plausible account of change to aid our understanding of time as nothing more than a measure of change.

As we have done of time, we ask of change, “what is it?” Aristotle cashes out change in terms of potentiality. Stated loosely, change is the process a thing undergoes as it moves from potentially being something to actually being something. For example, bricks have the potential to be a house and as they are stacked and mortared together, they undergo the process that ends in the completed house. The change in the bricks is defined by the move from potentially a house to in fact a house. Cashing out change and potentiality more precisely is where the difficulties arise. Two scholars in the field, Ursula Coope (2009) and Andreas Anagnostopoulos (2011), provide us with quite different ways of interpreting Aristotle.

The first section is devoted to Coope’s account and the second raises concerns about her account. Similarly, the third section deals with Anagnostopoulos’ account while the fourth considers objections to it.

Finally, in the conclusion, I give two reasons why an account like the ones discussed in this chapter are so helpful to my account of time. Before moving to section one, I begin with a note on the translation of Greek terms in Aristotle's work, which lies at the heart of the debate on interpreting Aristotle.

Aristotle defined change as the "*entelecheia* of the potential being, *qua* such [potential]" (Anagnostopoulos 2011, 33). Two of the difficulties in understanding Aristotle's definition arise, first, in the interpretation of *entelecheia* and, second, in his use of *energeia* as interchangeable with *entelecheia*. Where scholars favor using *entelecheia* to understand change, two ways they cash out their understanding are as change as a process of actualization and change as an incomplete actuality of a potential for being ["incomplete actuality" for shorthand]—Coope argues against the interpretation of change as a process of actualization and in favor of change as incomplete actuality. As we will see in the coming section, change as a process of actualization leaves the most important questions about change unanswered, whereas, understanding change as an incomplete actuality provides answers to those same questions. The second interpretative difficulty arises because, unfortunate for us, Aristotle uses another term, *energeia*, interchangeably with *entelecheia*. *Energeia*, however, does not mean quite the same thing as *entelecheia*. *Energeia* means activity. Traditionally, interpreters have opted to translate it as 'actuality,' treating it as though it means the same thing as *entelecheia*. This translation worries scholars like Anagnostopoulos. He argues that we ought to favor the meaning of *energeia* over that of *entelecheia* and instead translate both terms as "activity" rather than "actuality." He readily acknowledges that favoring either term at the expense of the other is problematic, each in its own way. However, he concludes

that, to understand change in a way that remains consistent with the rest of Aristotle's thought, we ought to interpret both words as "activity" (Anagnostopoulos 2011, 36).

III.1. Coope: Change as the incomplete actuality of potential for being

Change is a thing's potential coming into existence, but not yet fully realized. Thus a pile of bricks, with the potential to be a house, begins the process of changing as it is formed into a house. The potential is incomplete, however, as long as the house is unfinished—for as soon as the house is built, the change ceases, the potential for a house is no more because there is in fact a house, and the bricks are no longer simply a pile with potential but, rather, changed to a house. Coope defines change as the "incomplete actuality of potential for being," where the incomplete actuality is the potential that is only partially realized—Coope further describes this change as "the actuality of what is potentially in some particular different state, *qua* such" (Coope 2009, 282). Four concerns motivate this definition.

First, Coope argues that we should understand *entelecheia* as 'actuality' rather than 'actualization' because it makes better sense of Aristotle by both accomplishing his aims and providing a stronger interpretation of his work. Aristotle aims to critique Parmenides' claim that change is impossible, as shown by Aristotle's reference and discussion of Parmenides (Coope 2009, 277). Since Aristotle aims to counter Parmenides' denial of real change, a good definition of change will protect the possibility that change is real. In responding to Parmenides, Aristotle also aims to explain what change is, but to say that change is the actualization of the potential being skips explaining the actual process of change and leaps straight to the finished product. "To define change as the process of actualization" is circular and leaves readers as unclear

about what the process of actualization is as they were about what change is (Coope 2009, 279). Leaping to the finished product misses the whole point of giving an explanatory account of change and leaves unsolved the question of whether change is possible (Coope 2009, 279-280).

The second reason for preferring ‘actuality’ over ‘actualization’ does not depend on our understanding of Aristotle’s goals and intentions but rather relies on making the best sense out of Aristotle’s work. Coope argues that, linguistically, interpreting *entelecheia* as a “process of actualization” is inconsistent with the way in which Aristotle uses it throughout the rest of his work. Moreover, this interpretation also makes the definition unnecessarily complex and the *qua* phrase superfluous. As Coope says, ‘Any process by which something that is potential is actualized is a change. Why then, is it necessary to add the qualification “*qua* such”? What is more, Aristotle himself makes it clear that this qualification is an essential part of the definition’ (Coope 2009, 280, Author’s emphases). With that observation, she concludes that the first requirement of a good definition of change is that it interpret *entelecheia* as actuality.

So the first quality we should look for in a good definition of change is that it actually explain what change is. That is, it should enable us to better understand what is incomplete and unreal, as Parmenides worried, and yet also real about change. The *qua* clause answers the concern, what change is, by distinguishing potentials as either ‘dormant’ or ‘actual,’ in the following manner. Any given thing may have several potentials. For example, a block of bronze has not only the potential to be bronze, but also the potential to be a statue or a cup or a ring, and on the list of potentials goes. However, not all potentials are equally active, that is, actual. If a bronze block is being

made into a statue, it is not being made into a cup or ring or any other number of things which it also has the potential of being. In this sense, then, Coope argues that some potentials are dormant—not coming into being. However, where a potential is being brought about, it is then an actual potential and not merely dormant.

It would be natural for us to wonder how we are to distinguish between actual and dormant potentials. Actual potentials are those potentials that are making a difference to the way the world is now, but only a particular sort of “making a difference” counts as actual potential. Coope notes that careful attention to the meaning of “making a difference in the world” is necessary—after all, there might be many ways in which a dormant potential makes a difference in the world. She gives the example of a tyrant who wants to prevent the making of bronze statues and so orders all bronze locked up in the royal vaults. In this case, this dormant potential of any piece of bronze, i.e. to be a bronze statue, is making a difference in the world, but this is not the sort of difference in which Coope is interested. Instead, she argues that “for a potential for being F to be actual at a certain time, it is not enough that that potential is making a difference to how the world then is: it must be making a difference in a way that is (in some sense) *directed at being F*” (Coope 2009, 283. Author’s emphasis). There are then just two ways left for a potential to be actual: either the bronze is already a statue or it is in the process of becoming a statue.

The second quality we should expect of a good definition is that it differentiates the process of change from the product of change. Otherwise, the definition is not actually explaining the process of change, but merely restating the same puzzle over again. Again Coope turns to the *qua* phrase to answer this concern. “When Aristotle

says that change is the actuality of what is potentially F, *qua* potentially F, the point of the *qua* clause is partly to emphasize that the actuality in question is the actuality of something insofar as it is merely *potentially* F. A thing's potential to be F is most fully actual as a potential, when the thing is not yet F. It is this incompleteness and yet also actuality of a potential that leads Aristotle to say of the process of building a house that "the actuality of the buildable, *qua* buildable, is the process of building. For the actuality is either the process of building or the house, but when the house is, the buildable no longer is" (Aristotle, *Physics III*. 201b 9-11, from Coope 2009, 283). Coope concludes that change is the incomplete actuality of a potential for being in some new state; it is a thing's incomplete becoming of something new without yet having finished the becoming of that new thing. Once a potential is fully actualized, there is no more change, there is no more becoming. The potential has been actualized, the bronze is a statue and the building supplies are a house.

Change is in-between the bronze's potential to be a statue and it's actually being that statue, that is, it is the move from dormant potential through active potential but not yet realized potential: this bronze will be a statue as opposed to a door knob or a bed frame or any other number of dormant potentials it has. Although the potential is now actual, in the sculptor's work, since the statue is not yet complete, the statue is not yet actualized—as soon as the sculptor finishes the work, there is no more becoming left and only then does the actual potential become the actualized statue. The *qua* statement, Coope argues is meant to pick out just such cases of the incomplete actualities of potentials. Understanding change and the *qua* phrase in this manner, allows us to make

sense of Aristotle's claim that "the potential, of which it is the actuality, is incomplete" (Aristotle, *Physics III*. 201b 32-33, from Coope 2009, 283).

Clarifying process from product also provides further clarity regarding Aristotle's response to Parmenides. Potential ceases to exist when once it is actualized—that is, a thing is potentially F just until it is actually F, at which point it ceases to be potentially F. Coope argues that

we can now see why Aristotle thought there was something right about his predecessors' associations of change with difference and what is not. A change is the fulfillment of a potential something has to be different from how it currently is (or, equivalently, to be in a state in which it is currently not)" (Coope 2009, 283).

The irony about the nature of change, then, is that it aims at its own destruction.

Finally, a good definition should explain why the *qua* clause is so important to Aristotle. Coope argues that the *qua* clause is key to providing the first two conditions of a good definition. The *qua* clause is important because it distinguishes "*changing from having the potential to be in some new state without changing towards it*" and also allows us to distinguish between the process of change and the state resulting from that change (Coope 2009, 282). Here we might think of the differences between the possibility of brick becoming a house, the brick being built into a house and a built brick house. Without the *qua* clause, we do not have a good means of distinguishing between the potential that is dormant and the active potential, that is the possibility of the brick becoming a house and the brick currently being built into the a house. With the *qua* clause, we say that the potential of the brick is in fact coming into being, i.e. brick being built into a house.

III.2. Considering Coope's Account

Coope raises three potential problems for her account of change as actuality, and I follow up those discussions with a critique from Anagnostopoulos. First, from Robert Heinaman she takes the critique that her account does not make room for Aristotle's claim that "the action of changing something else is itself a kind of change" (Coope 2009, 285). Heinaman's worry points to Aristotle's distinction between agency and patiency, both of which can result in changes. The "class of changes includes not only changes that a thing undergoes (such as *becoming a house* and *becoming a sculpture*), but also what we might call 'transitive changes': actions of producing change (such as building a house and making a sculpture)" (Coope 2009, 285. Author's emphases). A revised definition of change for transitive changes would be that change is "the actuality of what potentially acts and what potentially is acted upon *qua* such" (Coope 2009, 285). Heinaman worries, however, that this definition cannot be consistent with the earlier definition, namely that change is "the actuality of what potentially is, *qua* such," unless the potential referred to in each case is "a potential for *changing*, rather than a potential for being in some new state" (Coope 2009, 285). However, this problem can be solved, Coope argues, by saying that "the agent's potential that is actual during the change is, in fact, a potential for the being of a new state, but that it is a potential for the being of a new state in the patient rather than in the agent" (Coope 2009, 285). Coope readily acknowledges that no new state results for a builder simply from building a house—the new state occurs for the house. She also acknowledges that Aristotle claims that the change occurring from an action such as house building is a potential realized through the change to something

else's state and the change to the agent comes through the relation of agent and patient (Coope 2009, 286; and Aristotle, *De Anima* II.5, 417b8-9). Instead, she argues that

“the state that the agent's potential is directed towards is a state not of the agent, but of the thing the agent acts upon. The housebuilder's potential to build a house is a potential the house builder has for the being of a house [...] Of course, it would be a mistake to say that the housebuilder is potentially a house. The housebuilder, unlike the bricks and mortar does not become a house. But nevertheless, the house builder, like the bricks and mortar has a potential the complete fulfillment of which is a house. The incomplete actuality of this potential of the housebuilder (or in other words, the actuality of this potential, *qua* potential) is the action of housebuilding” (Coope 2009, 286).¹⁵

While we might at first find the idea that an agent's actualized potential comes through the changes they cause in some other thing, in this case the housebuilder to the built house. She suggests that it is precisely this oddity that Aristotle aims to address when he notes that “the activity of each thing will not be in each thing” (Aristotle, *Physics* III.3, 202a33-34) and goes on to note again in the *Metaphysics* “that the teacher demonstrates his craft by exhibiting the pupil at work: to see the fulfillment of the teacher as a teacher, one must look at what the pupil is doing (Aristotle, *Metaphysics* 8.1050a17-19, from Coope 2009, 287).

Another concern Coope raises about her interpretation of Aristotle is that it puts his account of change at odds with another account of change that he endorses in *Physics* VI. There he says that, “anything that is changing has already changed and that anything that has changed must previously have been changing,” (Aristotle, *Physics* VI.6, 237a17-19, from Coope 2009, 287) by which he means not only that “for any moment during a change, there must have been a previous moment at which that change was already occurring, but also that any moment during a change must be a moment at which *another* change is complete” (Coope 2009, 287. Author's emphasis). This alternate discussion of

¹⁵ For a more complete discussion of this objection and Coope's response see Coope (2009, 285-287).

change raises the worry of how we are to understand these infinitely many sub-changes a thing undergoes in its process of arriving at its end state in terms of actuality and potentiality. Are we to understand sub-changes as incomplete actuality of a potential for being or not? If we say no to that question, Coope notes, “then for every change that exemplifies the *Physics III* account, there are infinity many others that are counterexamples” (Coope 2009, 288). However, if we answer yes to that question, “then change as a whole seems to dissolve into its parts” (Coope 2009, 288). Coope responds that, aware of this concern, Aristotle clarifies in *Physics VIII*, that

it is impossible for a thing to complete a change without resting in the state to which it was changing. Thus merely passing through an intermediate state in the course of a change does not constitute the completion of a change to that intermediate state. On this via, though a movement is infinitely divisible in the sense that there are infinitely many points at which it could be interrupted, a continuous movement does not contain parts that are themselves movements (Coope 2009, 288).

We can understand *Physics IV* as describing how change relates to process, not through direct reference to process, but as a particular sort of process. A change, therefore, happens to be a certain sort of process. Understanding this relation between change and process also helps to further clarify Coope’s response to the concern that we might end up with an infinity of changes. While we might have infinitely many changes, it is not in a problematic sense of having an ‘actual infinity’ of changes if we instead think that it is the complete changes that are actual changes, where other changes are in some sense not individuated in a relevant manner (Coope 2009, 288).

Finally, Coope raises the concern that her interpretation of Aristotle results in an account of change that does not properly pick out all and only cases of change. The first problem is unending change—for example, the movement of the planets, which Aristotle

assumes is unending. This unending change is at odds with the idea that change is an incomplete actuality of potential aimed at some particular end state—there is no end state with the unending movement of the planets.

The second problem is agent caused changes that seem to have no intended end state, such as the unintentional kicking of a rock. Coope understands Aristotle as saying that “the agent of the change must in some sense already have the actuality towards which the change is directed” (Coope 2009, 289). However, when a walker happens to kick a rock, since she does so unintentionally, Coope argues, it is hard to imagine that the movement of the rock fulfills some potential to be in some particular end state, except by arbitrarily insisting that there is some end state at which the rocks movement will stop and so it had the potential to be in that state. Here it seems are two cases of change that do not seem to count as changes according to Coope’s definition because they do not realize end states in quite the right way.

The third problem is that a thing might remain in an unchanging state despite undergoing changes. Suppose that opposing changes result in a thing that has not changed but that qualifies as changing. For example, we can describe a stone as having two agents pushing the stone in opposite directions, such that it remains perfectly stationary. The stone’s potential to be at A is actual by the agent pushing the stone towards A, and the potential the stone has to be at B is also actual given the second agent pushing it toward B, but the stone has not moved. And so, since its potentials are actual and making a difference to the way the world is (given that it would move were either agent not pushing on it), in Coope’s terms, our stone is actualizing its potential to be at A or B, despite its stationary state. Coope’s concern is that the potential to be either at A or

B is a potential that is actualized, qua *merely potential*, since the stone is in fact at neither A nor B (Coope 2009, 290). Coope raises these worries for Aristotle's account but does not aim to provide solutions.

Anagnostopoulos, whose interpretation of Aristotle's account of change will come in the next section, offers further concerns about interpreting Aristotle as defining change in terms of actuality. His main concern is that there may not be a "genuine state of actually being a potential being at all" (Anagnostopoulos 2011, 39). According to Coope, dormant potential, pre-change, is not as real as the actual potential during change. However, it is not clear what difference lies between the dormant potential versus actual potential or between the actual potential versus simply actualized state. The oddity that Anagnostopoulos is concerned about is that dormant potentials are somehow less real than actual potentials and yet calling potentials "actual" seems an odd thing given that actual potentials are still only potential and not real until they have arrived at their final end state: the actualized *telos*. As Anagnostopoulos notes, the difference between bricks with the dormant potential to be a house and bricks with an actual potential (that is, which are in the process of becoming a house) is a matter of degree—neither has actualized the potential of being a house. Bricks that are in the process of becoming a house have perhaps actualized a different potential—that is, the potential to be in process of becoming a house. In other words, it is not clear how potentials could significantly differ in "being realized" if they are still supposed to be merely potential. The degree between these two stages (bricks with dormant potential and bricks with actual potential) does not obviously exist, since such a distinction seems to call for a prior potentiality—the more dormant 'potential potential being' as it were (Anagnostopoulos 2011, 38-39).

And so, he notes, “it is not clear that there is a genuine state of actually being a potential being at all” (Anagnostopoulos 2011, 39)¹⁶ Moreover, Aristotle’s explicit note that change is exclusive of its end would be rather confusing, Anagnostopoulos argues, were this actual potential state to exist, since for something to be actual in any degree is for it to contain its end or *telos* (Anagnostopoulos 2011, 40-41).¹⁷

Although Coope’s inclusion of “incomplete” in her definition of change as an incomplete actuality of potential might suggest that she is aware of the difficulties involved in talking about a middle stage between dormant potentiality and actuality, it is unclear that doing so resolves the tension. If change does not contain ends, but is a movement towards an end, then it is unclear in what sense a potential could be actual, be that incompletely actual or completely actual, while containing no ends. Left to our own devices we might make enough sense out of incomplete actuality to satisfy most of us. The trouble for Coope arises primarily because of Aristotle’s definition of change as excluding ends (Anagnostopoulos 2011, 43-44). Anagnostopoulos suggests that this sort of trouble arises with most modified accounts of actuality, that is, they begin to explain change and actuality in terms proper to other concepts and so import traits that expressly do not belong to change and actuality.

So, while Coope’s account appears to provide several positives, it also leaves us with a number of negatives. Her account apparently provides us with a defense of change as ontologically real and works to explain how defining change in terms of actuality

¹⁶ Anagnostopoulos gives the example of a “full grown child” as representing the kind of oddity involved in talking about actual potentials.

¹⁷ Anagnostopoulos continues his argument against Coope’s type of account on both a textual level as not what Aristotle is committed to and on a philosophical level as not making sense in the right sorts of ways. While Anagnostopoulos groups Coope’s account as part of what he calls the “Constitutive Actuality” account of change, he also notes that there are certain sorts of questions that Coope does not acknowledge as needing an answer (see pp. 38 footnote 10).

results in a definition of change that can distinguish between product and process. However, these very points, which we might consider strengths, may also prove more difficult to defend and explain than initially appears. As this section highlights, both Coope and Anagnostopoulos raise concerns that leave open the question of how successful Coope's account actually is.

III.3. Anagnostopoulos: Change as the proper activity of a thing's potential

Anagnostopoulos argues that we should understand change, for Aristotle, as the proper activity of a thing's potential. Change just is the doing of an activity that is proper to the *telos* of a potential. Returning to our brick, the brick changes when it participates in the activity of house building, which is the proper activity to the *telos* of the potential to be a house: namely a house. However, understanding change in terms of activity is an atypical interpretation of Aristotle. In a break from traditional interpretations, Anagnostopoulos argues that understanding change in terms of activity fits better with Aristotle's ideas as a whole. On several fronts, 'activity' provides solutions to problematic aspects of Aristotle's account of change that 'actuality' translations either compound or at least make no better.

First, circularity is a readily acknowledged struggle for translations where change is defined in terms of actuality because many of these accounts describe change as a process of actualization.¹⁸ However, because change is a sort of activity, Anagnostopoulos argues that defining change as a kind of activity better avoids that circularity issues. Although the move to translate both *entelecheia* and *energeia* as activity is novel, the idea that changes are activities is an uncontested notion in Aristotle

¹⁸ Coope makes this point as well but thinks she can and does avoid this problem by distinguishing process from product (2009, 279).

(Anagnostopoulos 2011, 60). Using *energeia* leaves space to distinguish between activities that constitute changes as well as activities that do not constitute change.

Second, defining change in terms of activity makes the need for ‘states’ unnecessary. Actuality accounts seem often to require a thing exist in one state before actualizing some particular potential and finally ending in some new state. Activity, in contrast, is about being and not becoming. Consequently, a thing can be or participate in an activity proper to itself without therefore moving from one state to another. Activities, unlike actualities, are not moving from a beginning state to an end state. Instead, activities often are their own ends and so in that sense are often already in a relevant state of actuality, rather than being about a transition into actuality (Anagnostopoulos 2011, 61).

Anagnostopoulos argues that Aristotle is concerned with change and activity as *being*, not *becoming*, and is therefore focused on the potential for being within four primary categories: substance, quality, quantity, and place (Anagnostopoulos 2011, 62).

He further clarifies that,

I mean potential being (*dunamei on*) rather than the power or capacity (*dunamis*) in virtue of which something is a potential being. For example...an acorn that is a potential tree rather than the acorn’s capacity to become a tree. Thus, for example, alteration is defined as the activity of what is potentially qualified, not of what is potentially in process of alteration, nor of the power or capacity (*dunamis*) to be or become qualified (Anagnostopoulos 2011, 62).

However, Anagnostopoulos readily admits that Aristotle’s regular use of ‘changeable’ and ‘alterable’ to talk about subjects of change is somewhat problematic for understanding Aristotle as meaning being rather than becoming. However as such uses are not fully explained and since interpreting them as ‘becoming’ raises other issues,

understanding change in terms of ‘being’ rather than ‘becoming’ is a more charitable read (Anagnostopoulos 2011, 62).¹⁹ Aristotle introduces change in terms of being potentially (*dunamei*) and being (*entelecheia*) as comprising one of four categories of being (Anagnostopoulos 2011, 62-63). Anagnostopoulos takes this particular introduction as an indication that change is about a specific category related to being:

The adverbial uses of *dunamis* and *entelecheia* here (200^b26-9) are meant to modify kinds of (categorical) *being*. That Aristotle intends to rely on a distinction between potential and actual categorical being is evident also from the very sentence that offers the first statement of his definition, where that distinction is repeated: ‘these having been distinguished according to each kind [*genos*] [of being], [being] actually and [being] potentially, the *entelecheia* of the potential being, qua such, is change’ (201^a9-11). In addition, since this is the first statement of the definition, it should be given significant weight. Finally, when Aristotle uses phrases of the form ‘what is F potentially [*dunamei*]’ in this chapter to talk about particular examples, he talks only about beings in the categories of quality and substance: ‘what is potentially cold’ (201^a21-2) and ‘what is potentially a statue’ (201^a30) (Anagnostopoulos 2011, 63).

Although understanding change as occurring in broader categories does not explain away the use of ‘alterable’ and ‘changeable’, Anagnostopoulos argues that we could understand such uses as implying particular kinds of changes a thing undergoes. It reveals not an inconsistency in language, so much as an eagerness to demonstrate the many ways in which his theory of change allows him to nuance, organize, and account for various kinds of change. Rather, through Aristotle’s quick move to show classifications of change he reveals his eagerness to demonstrate that “different types of change will be proper activities of different types of potential being” (Anagnostopoulos 2011, 63). Reading Aristotle’s use of these two terms as implying particular kinds of changes is consistent

¹⁹Anagnostopoulos points to the same circularity issues that Coope (2009, 281), raises when she notes that it is circular to define “change in terms of a potential to be changing” as scholars like Heinaman do (Coope’s interpretation of Heinaman (1994)).

and further suggested by Aristotle's particular interest in categorizing and classifying changes elsewhere in the *Physics* (Anagnostopoulos 2011, 63).

What work does the *qua* phrase do? As Coope was worried about distinguishing between dormant and actual potentials, so Anagnostopoulos is concerned about distinguishing between accidental and proper activities. He takes it as evident that Aristotle intends to distinguish between accidental and proper activities with the *qua* phrase, saying, "with the phrase "*qua* such" Aristotle makes it clear that he means the proper activity of a potential being, rather than just any, even accidental, activity of that being. The *qua*-phrase thus enables the definition to exclude activities that, strictly speaking, are activities of a being with which the potential being merely coincides" (Anagnostopoulos 2011, 64-65). Anagnostopoulos notes that where typical interpretations are worried about distinguishing between the process of change and the products of change, his interpretation cannot make this distinction. That distinction, however, is not necessary on his interpretation, since "products of change are not activities of potential beings" (Anagnostopoulos 20011, 64-65). We might worry that some end states include activity and Anagnostopoulos notes that where some ends do include activity, as in the case of "the activity of being human," as long as these activities "are proper activities of actual rather than potential beings, they will not be picked out by Aristotle's definition" (Anagnostopoulos 2011, 65, footnote 59).²⁰

What then does it mean to call something the proper activity of a thing's potential being? Anagnostopoulos argues that Aristotle's definition aims at distinguishing two entities that are causally related: "(material) cause and thing caused—the proper subject

²⁰ Anagnostopoulos notes that his account is at least consistent with a version of the Thomistic view of end states as including activities.

of change and the change itself that this subject undergoes” (Anagnostopoulos 2011, 66). Although the definition picks out these two entities, the subject of change and the change, which happen to be casually connected, that fact alone does not show that Aristotle is concerned with the casual relationship. Noting that point, Anagnostopoulos says

to call change the proper activity of something is to posit a causal relation between change and that whose activity it is. We may speak loosely of any activity a thing engages in as an instance of its *energein*. But to specify the activity as a being’s *proper* activity—as the activity of that being ‘*qua* such’—is for Aristotle to specify the activity as causally explained by that being (Anagnostopoulos 2011, 66. Author’s emphasis).

Although a thing might have various activities that constitute change, since a being’s proper activity is caused by that being we could define change as “the activity a potential being engages in *because* it is a potential being.” In defining change thus, Aristotle is able to specify the being that is undergoing the change, the potential of that being, as well as the intention, not merely accidental, activity of that being.

Furthermore, the *qua* phrase applies to one being and organizes that being’s potentials. For example, the potential that bronze has to be bronze versus the potential that bronze has to be a statue. In both cases, and the many more cases of potentials that bronze has to be any other number of things, the *qua* phrase identifies the common ground among potentials as well as allowing one to specify the particular potential. The common ground among potentials just is the one thing that has these various and specific potentials, or we might say the “beings that are merely one-in-number” (Anagnostopoulos 2011, 50). Bronze has the potential to be both bronze and a statue precisely because of the underlying single existence as bronze. The common ground between all of bronze’s potentialities is just that it is bronze. Aristotle gives another example of the potential for sickness and wellness as sharing in common the being who is

able to be either sick or well—that being is the one-in-number of which we can say it has many potential beings. So, when we want to refer to a particular potential, the *qua* phrase picks out that potential while at the same time also names the thing and its potential as one-in-number, in virtue of the fact that that potential being is a potential of that particular thing. In allowing us to make these finer distinctions, the *qua* phrase enables us to pick out and specify activities proper to a potential being. The *qua* phrase allows us to be exclusive about activities, rather than accidentally including “activities of being with which the potential being merely coincides” (Anagnostopoulos 2011, 65).²¹

If we doubt this need, if we think that the bronze and its potential are in fact one and the same, without distinction, Anagnostopoulos reminds us that we would be committing ourselves to thinking that a thing’s having the potential to be a statue imbues the same qualities as does a thing’s being bronze. But to think that “the *entelecheia* that belongs to something in virtue of its being bronze would also belong to it in virtue of its being a potential statue” is to mistakenly reorder the causal relationship. The activity that belongs to some thing *x*, because *x* is, say, bronze, does not necessarily belong to another thing, *y*, simply because *y* has the potential to be a statue. Consequently, Anagnostopoulos argues, the *qua* phrase clarifies and narrows the scope of particular activities for which a thing has potential. From an array of possibilities comes the narrowing to specificity; and so by the *qua* phrase we can speak of the man engaging in the activity of building, *qua* builder, versus this same man engaging in the activity of curing, *qua* doctor. We discover that the man is the common one-in-number to the

²¹ Anagnostopoulos also notes that this interpretation also avoids the problem of needing to exclude products of change, which other interpretations face, because it avoids the issue entirely “since products of change are not activities of potential beings” (2011, 65).

variety of beings, e.g. builder and doctor, for which he has the potential of being (Anagnostopoulos 2011, 51).

Thus, we return to an earlier point, that the *qua* phrase picks out the proper activity of a being. By specifying that the man, as a builder, has the potential to build, we are able to distinguish between the activity of building versus the activity of curing that the same man has, *qua* doctor. Building, then, is the proper activity of the builder and the accidental activity of the doctor. Consequently, the man, as a doctor, engages in the proper activity of curing, however, as the builder, the man is merely coincidentally engaging in the activity of curing. And so we find that “the phrase ‘*qua* such [potential]’ will narrow the scope of the definition to one among what are, in this loose sense, several *entelecheiai* of the potential being” (Anagnostopoulos 2011, 51).

III.4. Considering Anagnostopoulos’ Account

Anagnostopoulos addresses five concerns that scholars may have about his account. I then consider three additional issues not directly addressed by Anagnostopoulos.

The first concern Anagnostopoulos addresses is the concern that his account does not leave Aristotle with a compelling response to those who called into question the ontological status of change, such as his Parmenidean predecessors. The actuality interpretations are typically favored for their ability to provide a strong rebuttal to the notion that change is not real, whereas, the activity account provided by Anagnostopoulos does not provide grounds for such a strong response (Anagnostopoulos 2011, 67). This apparent failing, Anagnostopoulos argues, is less a failing than it initially appears when once we explore Aristotle’s aims as well as the actuality accounts more carefully. Rather than attempting to respond to his predecessors, Aristotle is attempting to structure

knowledge according to standards of truth (Anagnostopoulos 2011, 68). While Aristotle may counter his predecessors, where they fail to meet such standards, Anagnostopoulos argues that Aristotle is not primarily concerned with responding to their views.

Moreover, even supposing that he was so concerned, the actuality account does not sufficiently address the ontological status of change. The arguments given by his Parmenidean predecessors are left unanswered by actuality accounts. Although proponents of actuality accounts typically take these accounts as affirming the ontological status of change, they are mistaken. Anagnostopoulos points out that if we understand change as actual potential then we arrive at change as still only potential which leaves it open to the charge that change is still not real (Anagnostopoulos 2011, 68). Still, inasmuch as Parmenides and others mistook the structures of knowledge and standards of truth, Aristotle's account, on Anagnostopoulos' interpretation, does provide a critique to their accounts.

Anagnostopoulos argues that properly understood, we should read Aristotle's critique of his predecessors as addressing and correcting their mistaken notions of formal principles. Parmenides, and others with him, oversimplified the idea of coming-to-be as a move from 'what is' to 'what is not', resulting in their mistaken conclusion that change is not possible. Instead, they ought to have realized that there is a third kind of being that accounts for the transitional aspect of change. Had they properly grasped the formal principles of change, by Aristotle's account, then they would have understood that "that out of which, *qua* itself, things come-to-be—matter—must be one-in-number with, but distinct-in-being from privation" (Anagnostopoulos 2011, 69-70). Thus, change is a third kind of being—it is the matter, or material cause that brings about the 'what is'. We now

have the ‘what is’ (or the form), the ‘what causes’ (or the ‘material cause’), and the ‘what is not’ (or the privation)—three, not two, explanatory principles of change. As Anagnostopoulos phrases it, “an intrinsic relation between a potential being and the change it undergoes is required for potential being to play the (unmistakably causal) role of matter in a change, i.e. as that out of which, *qua* such, something comes-to-be” (Anagnostopoulos 2011, 70).

Nor is it the case that actuality accounts need merely translate this dialectic definition of change into terms of actuality. Anagnostopoulos points out that reinterpreting ‘actuality of potential being’ to mean ‘proper actuality’ does not sufficiently acknowledge that, according to Aristotle, “an entity is not in general the material cause of its own ‘constitutive actuality’” (Anagnostopoulos 2011, 70-71). And so we come to realize that Aristotle’s point in giving an account of change was to critique competing accounts, not for their stance on the ontological status of change, but, rather, for their insufficient understanding of the necessary and sufficient conditions of change (Anagnostopoulos 2011, 72).

The second issue one might worry about is product versus process. Where actuality accounts struggle to distinguish the process of change from the end result of change, this distinction becomes a non-issue for an activity account. Anagnostopoulos dismisses this issue, on the one hand because product versus process makes little sense on an understanding of change as an activity and, on the other hand, because what sense can be made of this worry is quickly dispelled, he argues, by the fact that products of change are not activities, generally speaking (Anagnostopoulos 2011, footnote 44).

Third, we might worry about the break with tradition in prioritizing *energeia* over *entelecheia*. While most accounts give precedence to Aristotle's use of *entelecheia*, actuality, over his use of *energeia*, activity, Anagnostopoulos argues that they do so at the cost of ignoring Aristotle's broader ideas (Anagnostopoulos 2011, 77-78). By contrast, change as an activity is a concept consistent with Aristotle's larger framework. Moreover, interpreting *energeia* as actuality requires ignoring Aristotle's central goal, which is to define change as focused on the *telos*. Change is the proper activity of a thing as it moves towards its *telos*, or end.²²

Fourth, Anagnostopoulos argues that his account avoids circularity as well as any actuality account does, thereby demonstrating that the concept of actuality is not necessary to avoid circularity. Where many actuality accounts struggle to sufficiently exclude the notion of change from their definition of change, activity, as a broader category than change, defines change without becoming circular. We might think of certain sorts of activities, like god's contemplation of theoretical principles, as activity without change. Anagnostopoulos cites examples of actuality accounts that define actuality as a 'potentially becoming' and 'being in the process of becoming,' phrases which do not properly distinguish between product and change and so risk circularity. Instead, he suggests that we favor 'potential being' over 'potentially becoming.' While stronger accounts, such as Kosman's (1969), use the *qua* phrase to distinguish between product and process, and so avoid circularity, they do so at the cost of natural interpretations (Anagnostopoulos 2011, 34). In support of that claim, we have already seen Anagnostopoulos argue against the ill-fitting 'actuality' interpretations. As already noted under the second point, defining change in terms of activity easily allows for

²²A full treatment of Anagnostopoulos' argument from context can be found on pages 73-77 (2011).

distinguishing between product and process, since, he notes, activity is not only a larger category than change, but also simply not a process of becoming and so not easily confused with products or end goals of any potentials (Anagnostopoulos 2011, 63).

However, Anagnostopoulos owns that there exists a deeper circularity in Aristotle, but that issue, he notes, is as much an issue for actuality accounts as it is for his activity account. The issue is that talking about potential being, ultimately, is only understood in terms of change. The power or capacity (*dunamis*) by which a thing has the potential for being anything is itself best understood in terms of change. Of this concern, Anagnostopoulos remarks “that even talk of potential being (*dunamei on*), for Aristotle, can ultimately be understood only in terms of change. For there is only one analysis of the term *dunamis* that could plausibly be taken to be a definition of the term, and it characterizes *dunamis* in terms of change” (Anagnostopoulos 2011, 64).²³ But as he sets this circularity aside for later discussion, I too will set it aside.

Fifth, Anagnostopoulos points out that for any account, it is difficult to arrive at a definition of change that results in the proper scope. Actuality definitions often struggle to properly pick out things that qualify as change versus those that do not. He notes that his own account may face a similar struggle, though not to the same degree. While activity is more successful at properly distinguishing instances of change, it still struggles to exclude three kinds of activities. Activities is a larger category than change and Anagnostopoulos suggests that “(i) the realizations of *hexeis* discussed in *De anima* 2.5, such as seeing and contemplating, (ii) end-containing activities as specified at *Metaph.* 6, 1048^b18-35, and (iii) transitive agency—an agent’s acting on (even changing) a patient” are three types of activities that a proper definition of change should exclude

²³ Here Anagnostopoulos cites *Metaph.* I. 1045^b32-1046^a19 for the definition of *dunamis*.

(Anagnostopoulos 2011, 61). Outside of briefly mentioning these activities and that there is much debate around them, he does not address the issue further and so I too set it aside.

Perhaps, for metaphysical realists, the most glaring downside of Anagnostopoulos' account is that he leaves open and even argues for an agnostic stance on the ontological status of change. He argues that Aristotle was not concerned with the reality of change, so much as the proper metaphysical understanding of potential being as the material cause of the change that is proper to it. Although Anagnostopoulos' account does not commit, one way or another, to the ontological status of change, it does preserve the scientific respectability of change as a subject of study, which, he says, was, Aristotle's primary aim (Anagnostopoulos 2011, 35-36). Anagnostopoulos pointedly does not call into question the reality of change. He merely argues that that question is not the question Aristotle was primarily concerned with addressing.

Accepting Anagnostopoulos' account, need not, then, require an agnostic stance regarding the ontological status of change. It only requires the minimal admission that the ontological status of change was not the motivating issue behind Aristotle's exposition on change. I raise this point since I aim in my account to question the ontological status of time without therefore requiring that metaphysical realists abandon all their realist commitments in order to accept the account of time I provide. Since I suggest that time is a measure of some real thing, namely change, it seems equally important that I offer accounts of change that can preserve the positive ontological status of change. Anagnostopoulos' account of change does preserve space for viewing change as real, even while reconstructing our understanding of Aristotle's primary aim in defining change.

III.5. Conclusion

In this chapter, I have suggested that one direction in which we might turn to define change is an Aristotelian one. I expressly have not, however, attempted to provide just one interpretation of Aristotle's views on change, in part to avoid entanglement in the larger debates about what Aristotle intended and in part because there may well be other accounts of change wholly disconnected from Aristotle that might also work with this view of time. Whether the accounts given in this chapter properly interpret Aristotle is largely beside the point. Even were one or both of these accounts wildly inaccurate regarding a representation of Aristotle's thought, they might still be just as useful to us here, if we find them convincing accounts of change. The aim is to provide just enough a glimpse of how we might define change to make my larger project of calling time a measure of change a sensible endeavor. To this latter aim this discussion of change helps my account in two important ways: 1) defining change without reliance on the concept of temporal process, 2), by adding something interesting to our understanding of how we go about measuring the world around us.

What both interpretations, Coope's and Anagnostopoulos', share is their attempt to give an account of change that does not presuppose a temporal process. We see this most explicitly when Anagnostopoulos gives an account of activity as a broader category than change and, though not directly noting a lack of reliance on the notion of time, does note that there are activities without change. We have then some reason to think that there might be activities that do not unfold as temporal processes as well—again, god's contemplation serves as a nice example of what such a timeless, changeless activity might be like. The fact that both accounts, even unintentionally, provide an account of

change that does not help itself to the idea of a process that unfolds in time is particularly helpful for my project. To claim that time is merely the measure of change means that I will want an account of change that avoids defining change in terms of time. These Aristotelian interpretations, and any other accounts of change that likewise define change without reference to time, allow the sort of account of time that I offer to avoid charges of circularity while also saying something interesting about what we are doing in our work on measurement.

The second interesting thing that these kinds of accounts of change offer to my project is that they help us to explain why we choose to use certain kinds of changes for our measurement practices. Why do we search for and then use certain kinds of repeating changes, such as changes in cesium atoms? We often talk about the periodic process involved in the various changes we use and make the mistake of imagining that the reason we find these periodic processes so useful is because they measure time. Rather, we find certain repeating changes useful because they are distinct and regular enough for us to identify, in some real and meaningful sense, in their stages of being. While we face all sorts of uncertainty and constructive work, in certain changes, like cesium atoms, we find the move from existing in one energy state, with the potential to exist in another (i.e. hyperfine state), and then the actualization of that hyperfine energy state (and return back to a lower energy state), captures both our understanding of change and being and also our pragmatic need for distinct and measurable realities. Energy states in cesium atoms, and other physical changes like them, provide a much more accessible reality on which to base our measurement tools because their move from potential for a new state to actualized new state is more accessible to us. These changes are not perfect in the ways

we might hope and still require constructive work in order to be of any use to us, yet we consistently find that certain periodic process, that is, repeating changes, are of particular use to use. Accounts of change like the ones in this chapter allow us to better understand why certain repeating changes are so useful. This account of change, whether understood as an activity or as actuality of potential being, allows us to pick out change as distinct from both the potential being and the *telos* or end state, which we need to be able to do when we measure change. Certain repeating changes make it easier for us to distinguish one change from another because in those repeating changes the move from one state to another state is more obvious and accessible to us.

Chapter IV: The Metaphysics of Time

I have advocated using literature in epistemology of measurement to enrich conversations about the metaphysics of time and in this chapter I present three case studies where I do just that. I have also suggested that literature in measurement can enrich our understanding of the particular metaphysical account of time as a measure of change. As we examine questions of time in these coming case studies, the idea that time is nothing more than a measure of change is an increasingly more convincing account of time because it is able to provide more robust answers to these same sorts of questions than other metaphysical accounts of time, such as presentism, provide. The first case study is a discussion of Sydney Shoemaker's article 'Time without Change. The second case study considers presentists' conversations that range between metaphysics and physics as an example of how theorists use time and suggests that viewing time as a tool helps us to explain the different uses of time that we observe in these conversations. The third case asks whether, according to presentism, the present has duration.

IV.1. Measuring Shoemaker's Time

Sydney Shoemaker argues for the possibility of changeless time (Shoemaker 1993, 63-79). His argument is twofold: first, he suggests that the concept of time without change is logically possible, and second, he argues that a person could know about these changeless periods. It is the second claim that I shall examine in this paper.

I am interested in a particular sort of interpretation of Shoemaker's epistemic claim. I am interested in a particular sort of interpretation of Shoemaker's epistemic claim. Shoemaker gives us a thought experiment where he imagines a world that undergoes periodic freezes where change ceases. If Shoemaker is merely claiming the epistemic *possibility* of knowing of these changeless periods, then I have very little to say. I willingly grant the conceptual point that one can inductively reason from isolated frozen periods to the conclusion that a universal freeze occurs. But if we consider a more interesting alternative interpretation of Shoemaker as aimed at making a subtler and more complex point about knowledge based on observation, in response to an argument from Aristotle, then the thought experiment moves from a mere exercise in conceptual possibility to asking what sort of epistemic work metaphysical thought experiments can accomplish. Whether Shoemaker intended this alternative interpretation does not change the interesting challenges that come with considering how the measurement of time would actually work in this imagined world. I will argue that once we imagine inhabitants with a robust epistemology of measurement into the thought experiment, there is good reason to suppose that a better account of that world exists and that we might think that Shoemaker's inhabitants are more likely to adopt it or something similar to it over Shoemaker's interpretation.

The first section of this paper examines Shoemaker's argument as a response to a worry from Aristotle. The second section considers epistemic issues within measurement theory. The third section brings those measurement issues to bear on Shoemaker's argument. I conclude by arguing that were we to actually attempt measurement in his

world, the assumptions Shoemaker makes are more complex than they initially appear, which would call into question the success of his response to Aristotle's concern.

IV.1.i. Understanding Shoemaker

Shoemaker begins by considering the metaphysical and epistemic possibilities of time without change. There are at least three possibilities that Shoemaker is trying to argue for: 1) the metaphysical possibility of time without change, 2) a general epistemic possibility of knowing about time without change, or 3) the possibility of a specific kind of justification that Aristotle raises. Options 1 and 2 are arguments that do not require the elaborate thought experiment that Shoemaker develops—still, they are the traditional interpretations of Shoemaker's argument and I do not aim to argue over whether they are the best interpretations of Shoemaker. I am interested in the possibility of the third interpretation, which requires imagining a more complex debate between Shoemaker and Aristotle. If we consider a more complicated version of the conversation that is occurring between Aristotle and Shoemaker, then we arrive at an interesting discussion about this thought experiment and its relationship to epistemology of measurement.

Suppose that we take Aristotle to be concerned with the possibility of a particular justification for claiming that time without change is passing; the possibility includes both how we justify that claim and what counts as evidence for it. First, I provide a brief review of the metaphysical possibility of Shoemaker's argument before turning to the epistemic point consideration.

IV.1.i.1 Metaphysical possibility of periods of time without change

Shoemaker begins with the metaphysical claim that, laws of physics aside, periods of time where no change occurs are possible. By ‘change,’ he means physical change. Here Shoemaker explicitly has in mind Cambridge changes versus real changes (Shoemaker 1993, 63-64). For example, a thing or event that recedes ever further into the past is continually and inevitably changing by becoming older and older. Although Cambridge changes can include real changes, that is, metaphysical changes to the intrinsic properties of a thing, they are usually taken to imply no substantial change to a thing. While Cambridge changes are real in one sense, Shoemaker notes that they are not typically the sorts of changes a person means when she says that time is tied to change (Shoemaker 1993, 64). Attempts to distinguish “real” changes from Cambridge changes are fraught with difficulty and disagreement, but I set such issues aside in this paper (See McTaggart 1927 and 1980; and Geach 1969).

Physical laws provide potential grounds for objecting to the idea of time without change. Shoemaker asks that we set aside the particulars of our physical world, which might make time without change impossible in *this* world, so that we can see that there is no metaphysical impossibility in the idea. It might be the case, he notes, that in *our* world nothing does ever absolutely stop changing. Ceaseless change is a characteristic of the physics in our world, not necessarily an indicator that there is a problem in supposing that another world, governed by a different physical structure, must face the same sort of issue (Shoemaker 1993, 68).²⁴

²⁴Shoemaker does not further explore the interaction between physical laws and changelessness, for our own or other possible worlds e.g. 1) worlds in which laws prevent changelessness; 2) worlds in which the laws do not prevent changelessness, but in fact there is (‘accidentally’) no period of changelessness; or 3) worlds in which the laws do not prevent changelessness, and in fact there are periods of changelessness.

Additionally, Shoemaker addresses some possible measurement issues that might concern us. Verifying the existence of time periods void of real changes seems problematic because it seems that detecting an absolute lack of change at the molecular level would require an unattainable level of precision in our measurement instruments. It may be the case, Shoemaker notes, that *our* measurement instruments are not, and perhaps would never be, precise enough to measure an absolutely changeless state. But this limitation is a shortcoming of our world and our instruments, and does not necessarily lead to the conclusion that all possible observers in all possible worlds should face similar measurement constraints (Shoemaker 1993, 63).

By acknowledging these distinctions and difficulties between our world and other possible worlds, Shoemaker implicitly acknowledges the layers of theory that we must inevitably include in any measurement attempt. We use theory to help us understand what our instruments ‘do’ and what they tell us about the world, especially in cases where they are giving us information about unobservable things or properties, and even more so when they are giving us a ‘negative’ result (as in ‘the thing I’m measuring *lacks* property P’) (Tal 2016). Shoemaker’s inhabitants, therefore, will require extensive theory to move from observation and measurement-outcomes to the inference of ‘changelessness.’ I return to these issues later.

IV.1.i.2 The epistemic possibilities

Granting the metaphysical possibility of time passing during which no changes happen allows us to move on to the epistemic possibilities.²⁵ Shoemaker is explicitly responding

²⁵Shoemaker addresses the metaphysical possibilities of moving from changeless states to changing ones (1993, 73-77). For example, how might a world in a changeless state begin changing, that is, what

to Aristotle's worry that entertaining certain metaphysical possibilities is pointless because we are unable to observe the truth of them and therefore such possibilities are useless to us (Shoemaker 1993, 70-73). Before we clarify Shoemaker's argument, Aristotle's concern needs further consideration.

Shoemaker is responding to a passage from the *Physics* in which Aristotle argues,

But neither does time exist without change; for when the state of our minds does not change at all, or we have not noticed its changing, we do not think that time has elapsed, any more than those who are fabled to sleep among the heroes in Sardinia do when they are awakened; for they connect the earlier 'now' with the later and make them one, cutting out the interval because of their failure to notice it. So, just as, if the 'now' were not different but one and the same, there would not have been time, so too when its difference escapes our notice the interval does not seem to be time. If, then, the non-realization of the existence of time happens to us when we do not distinguish any change, but the mind seems to stay in one invisible state, and when we perceive and distinguish we say time has elapsed, evidently time is not independent of movement and change (Aristotle, *Physics*, IV, ch. 11, 218^b).

Aristotle might mean that there can be no empirical evidence for time without change or he might be claiming that there can be no experience of time without change. Which of these things he means may depend on an underlying question of whether he thinks of time as a thing that is the way it is independently of human beings or thinks of time as more strongly connected to how we experience it. If the latter, that is, Aristotle connects time to how we experience it, then he may only need to claim that there can be no experience of time without change to make his point. In this case, Shoemaker's response will certainly miss the mark since Shoemaker grants that we cannot directly experience time without change. However, if Aristotle means to consider time as a thing that is the way it is, independent of us, then it seems that he is arguing that there can be no empirical evidence for time without change (i.e. time cannot pass without change). If this

causes the change in a perfectly changeless state? I bracket these considerations. See also Le Poidevin 2010.

is the argument Aristotle is making, then it raises questions about what counts as empirical evidence and Shoemaker's response is relevant. Shoemaker interprets Aristotle in this latter way, as do other scholars (see Le Poidevin, 2010).

Assuming that line of argument, Aristotle is asking what sort of evidence we can have to show that time is separable from change. He is arguing that "time cannot occur in the absence of change because we could not possibly notice such a period of time passing, since to do so would be to undergo change ourselves" (Le Poidevin 2010, 173). Aristotle specifically has in mind a justification based on experience and observation; that is, he is interested in knowledge arrived at from our own experiences of the phenomenon in question. Notice, then, that examples where we claim knowledge based on some authority, such as the voice of God, are not what Aristotle is interested in. We need to base our claim on the experience of the phenomenon of time without change, but we cannot because we have no access, no means of observing and experiencing such a phenomenon, were it to occur, unless we were ourselves undergoing some kind of change (Le Poidevin 2010, 173). It might be the case that Aristotle is making a rather extreme skeptical statement about what we can know with certainty, in which case Shoemaker has probably lost the debate before it begins. Shoemaker, at least, does not take Aristotle as intending to take an extremely skeptical stance on knowledge; nor will I.

To show Aristotle wrong, Shoemaker aims to provide a quite specific sort of thought experiment. For, as Le Poidevin notices of Aristotle's argument,

it is this kind of argument, which clearly has a verificationist ring to it, that is Shoemaker's target. Granting for the sake of argument that there could be periods of time without change, is it logically possible for there to be evidence that such

periods have occurred or will occur? If the answer to that question is “yes,” we can attach little weight to the Aristotelian argument (Le Poidevin 2010, 173).²⁶

Shoemaker’s thought experiment, whatever else it accomplishes, must give us an example of experience that counts as evidence for periods of time without change, if he is to answer Aristotle. In this light, Shoemaker’s peculiar thought experiment, filled with so many seemingly unnecessary nuances, begins to make sense. While Shoemaker is free to imagine a new physical reality and perfectly precise instruments of measurement, he must remain within the confines of the human ability to experience phenomenon around us and make epistemically reasonable claims based on that experience. So the question becomes, what would count as evidence for time without change such that we could claim to know of it? The whole of Shoemaker’s paper (and this one) is devoted to trying to determine when observations and experiences count as evidence for a particular theory. Is it possible to give evidence of periods of time without change and, if so, what would count as evidence?

It would have been easy for us to grant the *possibility of knowing* about such freezes, if that possibility did not carry with it the restriction that we come to know via experience and observation. Shoemaker is after people *like us* knowing, through empirical means like our own, about the occurrence of this phenomenon: periods of time without change. Shoemaker thinks Aristotle is wrong to think that we cannot have empirical knowledge of such periods (Shoemaker 1993, 70-73). So, Shoemaker’s inhabitants need to know of these freezes, but not via the voice of god or some other equally non-observational means. Rather, Shoemaker wants experience and observation to be the basis of his inhabitants’ knowledge of these freezes. Aristotle asks how a

²⁶In his article, Le Poidevin does not address the success of Shoemaker’s response to Aristotle’s worry; instead he considers the metaphysical possibility of time without change.

physical self in a physical world would know of these changeless periods of time, since every means by which we perceive relies on changes occurring in us and around us? Shoemaker responds by creating a world in which the inhabitants would have experiences that they endorse as evidence for time without change. Far from being an unknowable event, Shoemaker wants to show how knowable and informative to life such observations would be. If Shoemaker's inhabitants are supposed to be like us, then how we experience the world around us, what counts as evidence for our claims, and what we conclude from our observations, are important questions that land us squarely in the middle of epistemic issues in measurement.

Knowing of freezes appears difficult. Suppose that the universe could freeze for a year or a billion years. Those experiencing the world would never be aware of such freezes—this lack of awareness is part of Aristotle's point. For example, if I am talking when a billion year freeze of the entire universe occurs in the middle of my sentence, the next thing of which I am aware is finishing that sentence. How could I become aware of that billion years freeze?²⁷ More importantly, what would be the point in saying that a freeze had occurred? In fact, countless freezes could occur in the course of my life with absolutely no interesting implications for me or anyone else in this world. Here is the thought experiment that Shoemaker constructs to overcome these difficulties.²⁸

Suppose a world like ours, save in the sophistication of its measurement instruments and the physical possibility of absolute changelessness, is composed of three

²⁷Le Poidevin points out that one of Aristotle's concerns is about what the idea of time without change could possibly amount to on an epistemic level.

²⁸Although this thought experiment serves a dual purpose, the more challenging use of it is on the epistemic level, which falls between the extremes of mere logical possibility and reality. In this space, the parameters of what is allowed in the thought experiment are less defined. Following Shoemaker, I bracket the broader discussion on the value of thought experiments. For a more on thought experiments see Sorensen (1992) and Brown (1991).

regions: regions A, B, and C. Inhabitants observe that region A freezes every third year; region B freezes every fourth year; and region C freezes every fifth year. The freezes in each region last a year and inhabitants of unfrozen regions can observe the frozen regions where there is no change. Moreover, Shoemaker notes that even the people who were frozen can deduce the freeze by noticing that things they were observing in other regions undergo radical and instantaneous changes. Correctly or not, Shoemaker follows Aristotle in assuming that knowledge during a freeze of one's own frozen state is not possible.²⁹

It is worth noting that even in these observations, the inhabitants' deduction of the freeze must be theory-laden because both the observations and the inferences drawn from those observations rely on a complex web of accepted theories. As the next section considers more carefully, in order to attribute these radical changes to freezes, observers must have complex theories about things like change, time, physical relationships between regions, agent participation, and so on. However, Shoemaker supposes that the spatial discontinuity as well as the testimony of witnesses from other regions will enable inhabitants to conclude that their own region has undergone a local freeze (Shoemaker 1993, 69-70).

Up to this point, Shoemaker's world has not actually provided a segment of time void of change. So far, inhabitants use changes in unfrozen regions to determine the passage of time in the frozen regions. However, every sixty years, the pattern of freezing works out such that all the regions' regular freezes overlap causing a universal freeze. Shoemaker argues that by this point the inhabitants are sufficiently aware of the regular

²⁹Shoemaker assumes that awareness is tied to change and that we would not be aware, post freeze, that something just happened. While neither assumption is obviously right, I grant them for this paper.

occurrence of freezes in each region to deduce a *pattern* of freezes. Based on the *regularity* of regional freezes, inhabitants infer a pattern that supports a further inference to a universal freeze. On this sixtieth year, the simplest and most likely conclusion, which the inhabitants will reach, is that a universal freeze is about to occur or has just occurred (Shoemaker 1993, 71-72).

We have provisionally attributed a certain epistemic condition to Shoemaker's observers. In the next section, we will consider the epistemology of measurement to get a better sense of what we have just claimed on their behalf. It is important to recall that the point of the next section is not to show Shoemaker's thought experiment wrong. Shoemaker's story about his inhabitants is successful as far as it goes. The question is, "how far does it go?" He has given us a reasonable story that some of his inhabitants might end up believing, but it is not clear that belief in this story about their world will satisfy Aristotle. Does experience of the world around us work in the way that Shoemaker imagines, such that he can offer the experience of his inhabitants as evidence for time without change? To develop this question, I consider how we experience, observe, and measure the world around us in order to justify claims about it.

IV.1.ii. Epistemic issues in measurement theory

Work in measurement theory reveals epistemic difficulties that make measurement anything but a simple practice. Notions like regularity, stability, and agreement take on new complexity as metrologists work to pair our ideals with the imperfect world (Tal 2014, 12-14; see also Mari 2003, 17-30; Duhem 1998; McClimans 2010 225-40; and

Quine 1998).³⁰ For example, when it comes to keeping time, we commonly assume that clocks tell us what time it is. However, when we look at clocks, they do not agree with each other—they do not tick at the same rate. What are we to do with clocks that read different times? Whether we are considering crude time-keeping or precise time-keeping we will face similar problems; they differ only in degree. If we are imposing regularity on the world for our own purposes, then, what do we mean by “regular”?

All clocks exhibit irregularity. While we might like this feature of the world to disappear with increased attention to precision and accuracy, as a matter of fact, it does not disappear, even with the use of atomic clocks. When it comes to our atomic clocks, we *stipulate* that what is ‘regular’ is some average, or other interpolation, of them (Jones 2000, 50-67; Petit 2000, 307-316; and BIPM (Bureau International des Poids et Mesures) 2006). The harder we work to perfect our measurement practices, the more it begins to appear that ideal regularity is largely a condition we impose on our measurement results rather than a condition in which the world presents itself to us. Parsing out how much we impose regularity on measurement and how much regularity is a feature of our world is a complex issue. It is worth noting that I do not claim that regularities in recurring events, like the freezes in Shoemaker’s world or our sun rises, are somehow observer-imposed, rather than real. Instead, I am suggesting that if we find that quantities, like time, are, at least partially, constructed by the observer, rather than a straightforward fact of the world, then *what time is*, in part, may be determined by how we construct it. Nor am I suggesting that the world, Shoemaker’s or our own, is so irregular that there is no way to tell the difference between five years and four, but rather

³⁰While all these notions face similar difficulties, I focus on regularity because it seems to be the measurement quality that most closely corresponds to Shoemaker’s ‘pattern recognition.’

that, if observers come to realize that precise regularity is not a feature of the world, then it seems likely that they will conclude that regularity is a constructed concept to which the world does not, as an objective fact, perfectly conform.

Because the irregularities in the world make it difficult to arrive at our ideals of regularity, metrologists constantly work to bridge the gap between what we want and what the world gives us (van Fraassen 2010, 157-185). While there is something about the cesium atom and our atomic clocks that match our notions of regularity, they are not perfect matches. Metrologists must average the divergences and imperfections, tweak the data, and sometimes delete it altogether in order to arrive at a usable approximation of our ideal second (Tal, 2014, 4-14; and Petit 2004). In part, it is precisely because we bring with us an ideal of the patterns and regularities we want to measure that we are able to measure “regularities” in the natural world, despite the fact that even the closest realizations of regular occurrences remain imperfect and irregular. From commerce to coordination to any other number of pursuits, including everything from pragmatic and theoretical to scientific and social needs, our desire to use measurement for various purposes informs our ideal of regularity (Jones 2000, 141-60; Tal 2011, 1088-1089; and Galison 2003).

While there is a long debate centered on asking to what degree metrologists construct versus discover pre-existing regularities, what is most striking about this debate is that it raises concerns that the measurement claims we make about the world are partially driven by what we want to do with the measurement results (Tal 2014, 12-22; see also Mach 1919; Poincaré 1958, 26-36; Carnap 1995; Latour 1987; and Schaffer 1992, 23-56). We use our idealized notions about measurement and the world to mold

our observations into useful measurements. Our ideals and goals inform our observations; but this realization need not mean that there is *nothing* informative or restricting about the world (van Fraassen 2010, 144-145). We can opt for a middle position and conclude that the world does place bounds on our ideals, thereby restricting and informing the conclusions we make about nature, even as we recognize that we also inform and construct the ways in which we know the world (Tal 2014, 22-34; and Latour 1992, 272-94). Some might dismiss the issues raised here as only pertaining to one side or another of the realist/antirealist debates. It is important to note that, regardless of where one stands in that debate, the issues of measurement are just as pervasive and troublesome.

Perhaps most important in our debates regarding regularity is not *which* conclusions we arrive at but the self-reflection they require of us. Again, here is how we arrive at self-reflection: First, we have practical aims, such as meeting the train on time or coordinating laboratory procedurals with our theoretical constructs, that appear to be connected, in part, with ‘time’. Second, to achieve those aims, we use information obtained via observation of natural phenomena or purpose-built devices (clocks, etc.) to guide our actions. Third, sometimes the information is not good enough (we miss the train; we are unable to match theory to experiment to a desired level of accuracy). Fourth, we then try to make better observations or better devices. Fifth, we never fully succeed but we ‘need’ regularity for our purposes so we end up ‘legislating’ it rather than ‘finding’ it in the world (or our devices). Sixth, this act of legislation prompts some reflection on the whole procedure running through points 1-5. That reflection may then

lead to a conception of time, regularity, or whatever, as a concept constructed (or cobbled together from other empirical concepts) by us for our purposes.

As soon as we start having these debates about measurement, we become acutely aware of the role we play in arriving at the outcomes of our measurements. Our awareness of this role makes it a good deal more difficult to justify certain kinds of knowledge claims. Whether we think that we play a large or small role in constructing the very regularities we seek to measure, once the issue is considered, we remain aware of this uncertainty about the degree to which we construct versus discover. Furthermore, our theories inform our interpretations of our measurements (Van Fraassen 2012, 774; Tal 2016; and Hughes 1997, S333). The very possibility that we may, even partly, construct regularity makes us aware that even regarding our own relationship to the world we are left with theories. What we consider it reasonable to believe as true about the world is directly effected by our assumptions about our role in the world. Why should these issues be any easier for Shoemaker's metrologists?

There are perhaps some folks annoyed that I have raised issues of measurement when talking about metaphysical issues, but I would offer two reminders. First, Shoemaker and Aristotle allow that knowledge of (supposedly) metaphysical claims may begin with (or at least be informed by) empirical knowledge. Second, since we cannot measure time directly (always we measure changes in our attempts to study time), we face our own uncertainties about whether time exists and what it is like, which should make us sympathetic to the measurement issues that Shoemaker's inhabitants' face in attempting to discover the nature of time in their world.

IV.1.iii. Measuring Shoemaker's Time

What do these issues in measurement have to do with Shoemaker's world? After all, I already granted that Shoemaker's inhabitants can reason their way to his account of their world. Here is the concern: what makes a conclusion (drawn from observation) reasonable depends, in part, on background assumptions and theories. For example, one reasonable background theory that Shoemaker's inhabitants might develop is the theory that time is a measure of change. In that case, the reasonable conclusion to draw (from their observations) is *not* that there are changeless periods of time. Of course, one might dispute whether the inhabitants have deduced the best background theory, based on their observations, but resolving that question is just resolving the original debate about theories of time, which leaves us right where we started. Their freedom to adopt diverging sets of assumptions and so arrive at quite different accounts of their world is a problem if we are trying to provide evidence for *a particular account* of the world over other accounts, as Shoemaker is. Shoemaker imagines that his inhabitants will deduce that universal freezes occur because he assumes that it will be the simplest explanation. Shoemaker thinks it a given that the people in his world will recognize the same patterns and draw the same conclusions as he does. But why should they? Here is a closer look at an alternative story about Shoemaker's inhabitants.

As Shoemaker's imagined people explore theories on measurement, they may adopt any number of theories, including a theory that understands time as nothing more than a measure of change.³¹ Such a theory gives them no reason to suppose that time is anything more than a count of the cycles of a cesium atom. From that perspective,

³¹Julian Barbour (1999) explores a similar idea with respect to our own world. He suggests that physics gives us many reasons to think that time and motion are not real things but are creations of perception.

Shoemaker's inhabitants might view time as nothing more than a tool that they construct in order to measure change. For them the different lengths of time—a year, a day, an hour, a second and so on—are merely ways to measure the beginnings and endings of things, much as we might measure distance by the mile, foot, and inch. Temporal language like 'a minute' or 'a year' is simply a way of talking about and measuring changes rather than a reference to some metaphysical reality called time. Even if Shoemaker's metrologists conclude that individual regions freeze, since they measure those freezes by the changes in unfrozen regions, metrologists will have no reason to claim that a universal freeze has occurred. If time is a measure of change, then the very notion of universal freezes is, at best, the same as saying zero time has passed and, at worst, nonsensical. If there is no change, there is nothing to measure. With nothing to measure, the difference between a second and a year becomes indiscernible. The conclusion that Shoemaker thinks they would draw is actually meaningless on the view that they have adopted.

Shoemaker relies on the partial freezes to provide a sort of experiential evidence of the universal freezes; but whether they provide such evidence depends entirely on the background assumptions one brings to the observation of these local freezes. Shoemaker envisions inhabitants of his universe measuring freezes by, 1) non-frozen observers, 2) frozen observers, 3) non-frozen clocks, and 4) patterns of freezes (Shoemaker 1993, 69-70). It is not clear that any of these means of measuring local freezes are as simple as he envisions. Shoemaker sets aside the theory-ladenness of observation. But theory-ladenness is a crucial part of the story. Theories partially inform *what* we see. Theories about cause and effect, change, time, regularity, and so on, affect the sorts of claims we

make and the explanations we give about the world we see (Tal 2016 and 2014; and Price 1996, 3-5).

The first three ways of measuring freezes are applicable to local freezes, but at best provide affirmation only that local freezes happen. What will the inhabitants think of these first three kinds of observations? It is hard to say what theories they might develop to account for such occurrences. Suppose, they observe the vast fluctuation of rates of change between frozen and non-frozen regions and conclude that time is merely a means of talking about the fact that they are each living in regions of the world where their rates of change do not always align with other regions. For the first three means of knowing their world, inhabitants rely on changes in unfrozen regions to observe the frozen regions. Without the ongoing changes in the unfrozen regions, Shoemaker's inhabitants would have no means of knowing about the frozen region. Rather than suppose that time passes inside the frozen regions or even that such a thing as "universal" time exists for their world, they deny that there is a 'universal' time that 'ticks for everybody' while still making sense out of the idea of changeless time in some localized sense (depending on their other views about time). For them, there is no obvious reason to suppose that the local patterns of freezing imply a single universal freeze.

Without seeming to recognize the complexities involved in observations based on 1-3, Shoemaker moves on to suggest that the observation of local freezes gives his metrologists measurement method 4, pattern recognition. He rests their claims to know about universal freezes on pattern recognition. Shoemaker's metrologists recognize a pattern in freezes as they observe regional freezes and calculate how frequently these freezes occur. Based on the past pattern of freezes, they predict that a universal,

yearlong, freeze occurs every sixty years. Even if we chose to skip over the complexities of the first three means of measurement, the fourth means of measurement is even more complicated. Shoemaker rests the pattern recognition itself on an implied notion of *regularity* that his inhabitants hold.

Shoemaker's justification, based on pattern recognition, highlights some problematic assumptions. It is partially the theories we bring to the world that determine the sorts of patterns we see and the conclusions at which we arrive. With any attempt at pattern recognition, we must first assume a background. For example, when we ask what number, if any, comes next in this series: 8, 4, 2, 1, ..., the answer depends entirely on the background of the number series. Are we assuming integers or real numbers? What pattern we see and the answer we give about the number series depend on the background that we choose. Shoemaker assumes that his metrologists will choose the same background theories and measurement theories that he does. He assumes both that metrologists play no role in constructing the very regularities that they aim to measure and that they will understand themselves and their measurement practices as he does.

Just where Shoemaker expects them to recognize rigid and unvarying regularity by which to infer an unobservable freeze, his inhabitants may instead infer that the world in which they live is quite irregular. They might conclude that there are regular alterations in rates of change by region (i.e. regional freezes) and only occasional irregularities (no freezes every sixty years). Or, they might understand these regional alterations in rates of change as indicators of more pervasive irregularities in the physics of their world. There is plenty of space for Shoemaker's inhabitants to give a different account of regularity than the one he gives and to see different patterns than the ones he

intended. If Shoemaker is only after the possibility of knowing of these freezes then the possibility that his inhabitants might arrive at different conclusions about their observations does not pose a problem for Shoemaker. But, Shoemaker wants to show that evidence exists that *will* lead these inhabitants to draw the correct conclusions about their world.

Shoemaker is partially resting his argument on an inference to the simplest explanation. Some might think that I have made too much of the measurement difficulties. Even with simplistic notions of measurement, we can observe and make inferences to the simplest explanation. But what counts as the simplest explanation is itself going to depend on our theories about the world. What does it mean to say that something is simple? That question is its own paper. Assuming that we agree on what is simple, we have the further worry that simple explanations can be quite wrong. We want not just a simple explanation, but also one that makes good sense out of the world; and the degree to which it manages to be simple *and correct* will depend in part on the way the world is and in part on the way we see the world.³² Whatever we make of the desire to choose the simplest explanation, we should not imagine that it resolves Shoemaker's troubles.

It is worth noting at least one more layer of measurement that Shoemaker's inhabitants will encounter. If Shoemaker's metrologists are like us, then as they reflect on their process of theorizing they will develop theories about their own role in measuring and understanding their world. They will develop accounts about how their perspectives inform the observations that they make about the world. As they develop theories about their contributions to measurement, the challenge of trying to justify

³²Here I bracket discussions about what makes a theory *good* or *correct*.

knowledge claims about unmeasurable, unobservable, and universal freezes will become more difficult. It is not clear that these metrologists will develop an epistemic account that allows them to claim to have evidence of such freezes any more than we could claim to know that such freezes occur in our own world.

Initially, Shoemaker's neglect of measurement practices seems reasonable given his stipulations that his imagined world is physically different from our own and that metrologists there have superior instruments. And were he only after the possibility of knowing about such freezes, there would be no problem in such neglect. But Shoemaker is trying to give evidence that is based on observations. Observational evidence is, as we now see, a complicated foundation on which to rest his case. Shoemaker assumes that the difficulties of measurement in his world can be resolved via precise instruments.³³ We cannot solve Shoemaker's difficulties by dismissing the need for theory in measurement. Nor can we object that we have placed an unrealistic burden on inhabitants who live in a world quite different from our own and perhaps experience their world quite differently from how we experience ours; if such is the case, then they are not sufficiently like us to serve as a relevant counter-example to Aristotle's argument.

What then is the point in coming up with alternative accounts that Shoemaker's inhabitants might develop? Some might think, "so what if they develop different accounts, they could also develop the one that Shoemaker wants." True. But we must ask ourselves what sort of evidence observations 1-4 are actually providing if they can

³³It is not clear that we can make sense out of the notion of a 'precise enough' measuring device exactly because our theories determine the standards to which our measurement-outcomes must conform. For example, when it comes to measuring the velocity of particles, we have to distinguish between slow moving particles and non-moving ones. However, since one cannot rule out the possibility that there is no lower bound on how slowly a particle could move, there may also be no *upper* bound on the precision required of the instruments. Nevertheless, I grant the possibility of even this questionable notion to Shoemaker and his world.

support widely differing theories about the world. If we can use the very same set of observations to either affirm the existence of universal freezes or deny the existence of such freezes, then it is not clear what kind of evidence they are providing for or against universal freezes. If Shoemaker's inhabitants have experiences that are ambiguous enough to leave space for wildly different interpretations of their world, then it is not clear that they will be able to justify the sort of claim that Aristotle is after. We can argue over which background theories and assumptions they ought to adopt, based on their observations, but, again, that just is the original debate about time. These inhabitants can certainly build a reasonable account of their world to support their belief in universal freezes, but then Aristotle was not objecting to that sort of thing. Whatever kind of evidence these observations provide, it is not answering Aristotle's worry because it leaves standing the real worry that they have no way of assuring themselves that time without change exists. The observation of regional phenomenon does not replace observations of universal freezes and inhabitants do not have experience of the latter.

If the same evidence can support competing accounts of the world then it is not clear in what sense it supports any particular account. I am not suggesting that such evidence provides no support to the accounts that employ it; at the very least, it seems to provide coherence to the account. However, that sort of evidence and confirmation does not seem to be quite rigorous enough for Aristotle's purposes. It might be the case that the sort of evidence Aristotle wants cannot exist for any account, but on the interpretation of Aristotle that we have adopted, the question is not whether it exists at all but whether such evidence can exist *for periods of time without change*. It seems reasonable to worry that no observations attain a level that can provide unequivocal support for an account.

But then we have landed in the middle of radical skepticism over the possibility of knowing our world and Shoemaker's; most find that, at the very least, a boring place to be. However, observations that can support different and contradicting accounts of the world provide a sort of evidence that is not quite strong enough for the needs at hand. It seems, even to decide whether and how an observation provides the kind of evidence Aristotle and Shoemaker are after will require a good deal more theory regarding what counts as evidence for the world being a certain way.

The issue of theory in observation is an important part of determining whether Shoemaker's thought experiment is a successful response to Aristotle's claim. Whether we view a particular observation as confirmation for a particular reality or theory depends in part on a host of starting assumptions. Whether local freezes will count as evidence for a universal freeze will depend not on the inhabitants observing the local freezes but on the assumptions and theories with which they interpret those observations.

IV.1.iv. Conclusion

Unlike Aristotle, I have not attempted to claim that Shoemaker's end goal is unattainable. I have only aimed to show that, as of yet, Shoemaker has not attained it. I have shown that simple observation does not provide an answer to Aristotle's challenge in part because what makes the conclusions we draw (based on observation) reasonable depends on our starting assumptions and theories. Shoemaker wants to show that his inhabitants would correctly understand their own world, rather than merely denying the freezes or understanding them in some other way. But it appears that their ability to arrive at the correct conclusions requires that they adopt a quite particular set of assumptions, assumptions that their experiences do not oblige them to adopt. So Shoemaker would

need to stipulate things like: that his inhabitants know that their world is unvarying in its cycles; what theory they hold about regularity and their role in measurement-outcomes; that they observe only one pattern; and that they *will not* adopt radically different theories of measurement, change, and time from Shoemaker's own. However, if he starts stipulating these sorts of things, then it begins to seem as if he is building into his inhabitants' theoretical foundations the very conclusion towards which, he is trying to argue, their observations will lead them. Because they are free and, perhaps, more likely to adopt alternative accounts, it seems that the evidence Shoemaker offers is not as robust as Aristotle requires to justify a claim about time without change.

Although some people might be tempted to defend Shoemaker's account as facing nothing more than the usual difficulties that any inductive account about the world faces, this defense would be too quick. While Duhemian sorts of objections about theory ladenness and auxiliary assumptions are not a sufficient reason for discounting Shoemaker's argument, that he fails to recognize those starting assumptions or consider their effect on empirical evidence is cause for concern. I have not argued that the theory ladenness alone, or Shoemaker's failure to consider it, results in his argument's failure. Rather, I have argued that Shoemaker's answer to Aristotle's argument rests on the problematic assumption that observation and measurement are straightforward means of establishing evidence for a theory about the world.

Finally, Shoemaker's thought experiment highlights the importance of carefully considering the foundational assumptions one imports to a thought experiments. Where some might initially imagine that a thought experiment such as Shoemaker's is safe from the empirical struggles and considerations of our day-to-day lives, his world provides an

example of just how hard it is to sufficiently escape our empirical and epistemic constraints. Even so, his attempt raises interesting questions about what kinds of observations and experiences count as evidence for a particular account and what degree of confirmation, if confirmation is what we expect, evidence should offer.

IV. 2. Time as a Tool:

Measuring Change in Metaphysics and Physics

We might expect that if we study and talk about time long enough, then, as happens in many other areas of research, we will slowly converge on some sort of consensus about what time is and what it is not. Contrary to those sorts of expectations, discussions about time range widely from metaphysics to physics with conversations on each side often appearing incommensurable and with no sign of consensus in sight. On one side, we have discussions about things like existence and tense-logic and, on the other, we have space-time and cycles in cesium atoms. The divide is sometimes so marked that it appears physics and metaphysics really are using “time” to talk about quite different things. So how do we make sense of the disconnected, often seemingly chaotic, conversations occurring around theories of time? I suggest that viewing time as a measure allows us to reconcile many of the schisms occurring in conversations about time. Taking the old theory that time is merely a measure of change and developing a more robust account of measurement practices allows us to understand the role we play in defining the very things we aim to understand, especially at the metaphysical levels of our theories. Rather than arguing for the theory that time is a measure of change, I argue the more modest claim that this theory, when enriched by epistemic work in

measurement, can reconcile the seemingly disconnected array of conversations about time that are currently taking place.

First, using epistemological work on measurement practices, I develop a more robust notion of what it might mean to say that time is a mere measure of change. In the second section, I use one of A.N. Prior's articles that defends presentism against objections arising from relativity theory. I use Prior's article because it is, on the one hand, a fairly common discussion between metaphysical and physical accounts of time and, on the other hand, it rather clearly illustrates the oddities that often arise in these sorts of conversations. Finally, I show how a robust account of what it means to call time a measure of change helps us to appreciate the varied and diverging accounts of time that occur in Prior's article as well as in other conversations about time.

IV.2.i. Time as Measure of Change

An old suggestion is that time is nothing more than a measure of change.³⁴ Building on that idea, I use work in epistemology of measurement to explain why we might find it so compelling to view time as a measure of change. Here is the simple version of this argument, though I flesh it out more thoroughly later.

Let us suppose that time is nothing more than a measure of change. When we consider measurement, we discover that it is theory laden and informed by our specific aims, which is as true of measurements of time as any other kinds of measurements. We also observe that there are various discussions about the nature of time and that sometimes they talk past each other or about completely different things. But, if time is a

³⁴Aristotle, for example, may be one advocate of this view, though there is some scholarly debate on whether he intended to claim that time was *nothing* more than a measure of change or only that it was, in some sense, inseparable from change (see Coope 2001 and 2005).

measure of change and measures are informed by both theory and the aims of individuals, then our observation—that discussions about time diverge—actually make sense, and might even be expected. In turn, the fact that our starting supposition, combined with our knowledge of measurement, better explains our observation than do other accounts gives some credence to our starting supposition that time is a measure of change.

This argument gives us further reason for trying to better understand the nuances in epistemology of measurement and time-keeping practices. We also have more reason to pay careful attention to the various conversations that are occurring about time and to how we interpret these conversations.

IV.2.i.1. Epistemology of Measurement and Time Keeping

Although persons not involved in metrology often imagine that the process of measurement is a simple matter of observing the empirical world and recording what we observe, metrology is in fact complex. Indeed, as we delve into the epistemic foundations of the measurement outcomes we produce, we discover that “produce” is a far more accurate word to use than we might initially imagine. The process of arriving at a measurement outcome requires not only extensive appeal to theories prior to any data collection, but also many choices along the way about which data counts in any given measurement and about how to interpret the data that we do accept (Tal 2016).

The realities of measurement and time-keeping practices make the idea that time is a constructed measure of change more plausible, rather than less. When it comes to our standardized second and atomic clocks, we are measuring changes in energy levels of cesium atoms. So why not suppose that we are also using time to measure other aspects of change in other kinds of conversations? We already construct a standard measure

based on the minuscule changes in cesium atoms and then use that tool to measure other changes. We call this tool ‘time’ and instantiate it in a variety of ways that are apparent to us, such as: atomic clocks, ephemeris time, pendulum clocks, water clocks, etc. We use everything from electricity to pendulums to celestial movements. In each case we define time by a change and aim to measure that change, whether we measure by using the electrically induced changes in the shape of a quartz crystal for our digital clocks, the changes in position of our pendulum as it moves through a full cycle, or the changes in position of the moon against background stars for our ephemeris time. We use the instruments for measuring time that suffice for the given purpose, but those instruments might be insufficient for another purpose. We do not always need the accuracy of an atomic clock—often a digital one will work quite well enough—but, in other cases, nothing less precise will do. In all these choices, our aims guide our construction of time and decide whether we have constructed a measure that is “regular enough” for the present purposes.

As we explore the role of observers in constructing the very thing we aim to measure, the idea that the second is not so much a thing to be measured as a constructed measure that we can use to measure change grows more appealing, reasonable, and even intuitive. Still, to say that these measurement practices bolster an account of time as a measure, is not to say that measurement practices and theories require one to abandon metaphysical commitments to the reality of time.³⁵ It is to say, however, that measurement practices can not only support the move away from viewing time as existing absolutely independent of human construction but also that such a move,

³⁵ Eran Tal makes a similar point (2016) when he argues that his own model-based solution to the debate between constructed measurement outcomes versus observed measurement outcomes need not commit one to specific, metaphysical positions—realist or anti-realist.

combined with our improved understanding of measurement practices, frees us up to better understand the various conversations we have about time. It may also be worth asking ourselves whether we would care at all about time if it did not enable us to measure and talk about change? If not, then perhaps it was never really time that we cared about. On the other hand, we could insist that time is real and we could, as Poincaré points out, rearrange large portions of our theories to fit that commitment (Sklar 1992, 57). But why bother? What is at stake if we let go the ontological status of time? It appears much simpler to understand our theories in physics and in metaphysics if we embrace time as a tool and let go our dreams of time existing fully independent from ourselves and our decisions, actions, and concerns.

IV.2.i.2. Observing How People Use Time

As we look at the various accounts of time we find many that *appear to be* or *are*, at odds with each other. One might think that a disagreement between accounts of time means we must decide which theory is correct and which is incorrect. There is some reason to suppose presentism and special relativity are at odds, so which is correct?³⁶ I offer an alternative to how we think about the conflict—we can understand each account as an application of the tool, time, in an attempt to measure change in different ways, which accounts for the apparent conflict.

Understanding time as a measuring instrument allows us to reconcile both the uses we see theorists making of it and many of the differences between the accounts given. Some people want to focus on scientific problems while others want to focus on metaphysical problems and still others want to address social, psychological, and

³⁶I am not claiming that they actually are, but that the two theories seem contradictory enough that theorists routinely feel the need to slow down and consider each account.

practical problems relating to change. We talk about time, but in different ways and for different reasons. For everyone using time, the focus or lens they bring to their use will play a vital role in defining the kinds of outcomes at which they arrive and the sorts of conversations they have. Those bringing physical lenses will arrive at a different set of outcomes than those bringing metaphysical lenses.

Some people will and do explicitly deny this view of time, but their endorsement is not necessary to the usefulness of the account. Whether a theorist appreciates, recognizes, or acknowledges that they are using time as a tool does not change that they are using it as such. The view that time *is* in fact best understood as a tool, allows us to recover what is *worth* recovering in various accounts of time and appreciate what seems right in them without having to entirely discard them based solely on what seems wrong in them.³⁷ If theorists do accept this view of time, they are free to be more flexible in their evaluations of what theories of time are claiming and accomplishing.

Just as in questions of length, we, the wielder of the measurement instrument, use the instrument to help us arrive at the goals we first constructed and defined. We may be less familiar with the ways in which we set the parameters of our measurements of time than we are with this same process when it comes to length. For example, measuring the length of a coastline turns out to be quite complicated and can yield quite different measurement outcomes, depending on the scale metrologists apply and how they choose to define a coastline (See also Heo, Kim, and Kim (2009). Are they interested in tracking very small inlets along a coastline? And how do they define these inlets? For example, many choices must be made about the mouths of rivers, what portions of them count

³⁷This is not to imply, of course, that all accounts of time have something worth recovering; no doubt, many do not.

towards the length of the coastline, how much of the rock that juts into the sea counts as the coastline, and so on. Or, are they more interested in measuring the length of the coastline according to the distance a ship would have to sail? Our aim will determine the choices we make in what to measure as well as the length at which we arrive; and so the same coastline might end up having widely different lengths, each accurate in its own context. Our end-goals determine the parameters and background assumptions for the questions we ask and for the sorts of answers we can give and accept (van Fraassen 1988, 2010. See also Batterman and Collin 2014; and Boesch 2017).

We do similar parameter setting with time. Whether we measure changes in energy, temperature, or existence, we use the concept of time in different manners, each manner determined by the different goals and constraints of our various projects. For example, the physicist might measure changes in position or energy, for the purpose of testing or formulating a precise physical theory. The farmer might be measuring changes in temperature while the psychologist may aim to measure experience and consciousness. The metaphysician might be concerned with the sort of change that Aristotle called ‘coming to be and passing away’, or perhaps something else, like causal activity. Time, as an instrument, leads us to many different measurement outcomes, depending on the lens we wear, the parameters we set, and the questions we ask. More importantly, it should come as no surprise that some of the conversations using time turn out to be entirely disconnected from each other. The instrument cannot determine the interconnectedness and commensurability of the ideas discussed—determining such things are not within the scope of an instrument.

When we look at the ways in which time is used to measure change, we do find exactly these sorts of things occurring. We find metaphysicians using time to look at change with respect to existence and reality (Deasy 2017). We find the physicists largely using time to track physical changes. In one conversation, we are talking about time in terms of the real and the present and, in another, we find that a second is 9192631770 cycles of a cesium atom. Both kinds of conversations are about change, but about features of change that are so different as to admit of little to no overlap in conversations. The trouble comes when we confuse the resemblances between conversations with actual overlap in conversations; instead, we ought to examine the parameters that we set at the beginning of any study ought to help determine whether and to what degree different conversations about time overlap.

Viewing time as a constructed tool, rather than a real thing, allows us to understand why we find such widely diverging uses of time. We may also find both that we understand why these conversations are so different and that, in some cases, we bear no obligation to make them commensurate. In the various conversations about time, we find that people bring lenses, so to speak, through which they view and define the conversation—physical, metaphysical, tense-logic, and special relativity lenses, to name a few. With these sorts of lenses, people modify and construct time so that they can employ it as a tool in their conversations about various kinds of change. For example, in some contexts it might be important to have an account of the topological properties of time, that is, whether it is ‘continuous’ or ‘discrete’, while in other contexts this issue would not arise; in some contexts time might be used to determine ‘regularity’ (or deviations from regularity), while in other contexts regularity is not important.

In all these uses of time, it is odd that we do not always seem particularly aware of our shifts in focus between conversations or of our disparate uses of ‘time.’ Understanding time as a measure of change helps us to appreciate the sorts of shifts that we see happening in Prior’s article, though he is not fully aware of it himself. The next section is devoted entirely to explaining Prior’s article and the third to interpreting it in light of this section.

IV.2.ii. Prior and Presentism

In his article, ‘The Notion of the Present,’ A.N. Prior defends Presentism in two ways: first by an appeal to the logic of language and, second, by addressing concerns that might arise from physical accounts of the world. Prior argues that the present and the real are “one and the same concept, and the present simply *is* the real considered in relation to two particular species of unreality, namely the past and the future” (Prior 2008, 379. Author’s emphasis).

Before moving to Prior’s account, there are a few notes worth making. First, responses to Prior are long and varied and I set them aside for this paper.³⁸ Largely, they are of an entirely metaphysical and linguistic nature and I am more interested here with the intersection of the physical and the metaphysical. Moreover, I recognize that Prior’s defense of presentism is somewhat out of style these days since some metaphysicians doubt that it is reasonable to expect tense-logic to provide both a theory of metaphysics and of language (Meyer 2013, 92). While Prior’s use of tense-logic may be out of style, his attempt to defend presentism against objections arising from physics is a move that is very much in style. Most metaphysicians who refer to presentism also refer to relativity

³⁸For more on these responses, see most metaphysicians on time, including Ulrich Meyer (2013).

theory and the problems it poses for presentism (see Meyer 2013, Zimmerman 2013, and Crisp 2003, among many others).

IV.2.ii.1. Prior's First Defense of Presentism

In this article, Prior is concerned that we clearly express our claims about the real and the present. Prior argues that a clearer use of language helps make the virtues of presentism obvious. He thinks that we often make the mistake of setting the real along-side various other sorts of things, like imaginary and possible worlds, as though it were just another of many variously labeled categories in the world. But, the real is notably special. It is special in that it exists; by contrast, there is no corner of the world in which we find possible worlds or Greek myths existing. The real world is special in that it requires no qualifying prefix to tell us *that* it is real.

Nor does Prior accept the accusation that he is simply prejudiced in favor of the real against other ontological statuses. The real is special because it needs no qualifiers and we should not minimize this uniqueness by lining it up as a mere option amongst the many (e.g. the imaginary, the possible, the real, etc.). And so, we need not qualify expressions that pertain to the real world. The only time we need qualification is with respect to different kinds of unreality. *X imagines unicorns* or *there could have been unicorns*, are ways in which we qualify the ontological status of unicorns, but we need not bother saying that *there are no real unicorns* when we could, with the very same meaning, and without redundancy, say that *there are no unicorns*. To add these sorts of qualifiers is to misunderstand the importance of real things. Moreover, we obscure our concept of the real world by adding redundant qualifiers to various kinds of unreality. By saying that *there are possible worlds in which unicorns exist* or that *unicorns exist in a*

person's mind, we muddy our own understanding of the distinction between the real and the unreal. Prior points out that to say that *there are possible worlds in which unicorns exist* is just to say that *unicorns could have existed* and to say that *unicorns exist in a person's mind* is just to say that *a person imagines that there are unicorns* (Prior 2008, 379-380).³⁹ Redundant qualifying of both real and unreal things leads to confused thinking and articulation.

Turning to the notion of the present, Prior argues that while it is tempting to line the present up next to the future and the past as though it were merely another box by which to categorize things, such a picture misses what is so special about the present. Just as the real has unique ontological status, so too the present has a unique status, namely that it is real, while the future and past are not (Prior 2008, 381). The present, like the real, is special in that it requires no qualifying prefix to denote it as real. Prior notes, "To say that my lecture is present is just to say that I am lecturing—flat, no prefixes" (Prior 2008, 381). Properties of pastness and futurity are not the event itself, whereas, "the presentness of an event *is* just the event" (Prior 2008, 381). Moreover, to talk about a thing's past present or future present is just to say that it is either past or future, that is, that it was or will be real. To say that a thing is present is to say that it *is*—that it is real as opposed to unreal.

We might still wonder what counts as real or present. Is there a non-circular definition that picks out 'the present'? Is the present instantaneous, or does it have some minimal duration? What role does it play in physical theories or in causal relationships? And how does it relate to change (e.g., can things change 'during' the present)? These

³⁹Prior does not, in this article, go into detail about possible worlds and the meaningful claims we might make about their ontological status.

are a few of the sorts of questions we might like to have answered by an account about ‘the present.’ In this article, Prior does not attempt to give a precise definition of the present. Elsewhere Prior does make explicit that the present he is primarily concerned with the ‘present’ of tense-logic and we will later return to answer some of these questions on behalf of Prior (Prior 2003, 171). In Prior’s use of ‘time’, certain sorts of questions about time and change arise ‘naturally’, questions that do not arise in other sorts of conversations. We make different ‘demands’ of the concept of ‘time,’ but it is not clear that any single conception of time will be able to answer all the different questions, in all the different contexts that might arise.

IV.2.ii.2. Prior’s Second Defense of Presentism

Prior then turns to the sciences to suggest that tense logicians face a challenge from physics and philosophy of science when it comes to tracking change and the present. Prior has in mind the special theory of relativity when he suggests that the difficulties rising from physics are about how one might arrive at a universe wide, simultaneous present. Special relativity turns simultaneity into a relationship between space-time events (points) and observers (represented by a ‘path’ through space-time)—what counts as ‘happening now’ is relative to the observer. Which events count as simultaneous to each other depends on the perspective from which those events are measured. Events A and B may happen simultaneous to each other from one perspective, but from another A may happen before B or visa versa. Thus, according to relativity theory, the objective fact about simultaneity remains relative to the observer. The worry for presentism, then, is that there is no ‘now’ that is common to all observers and that we can designate as

special or more real than the past or future. Rather, what is past, future and present become a matter of perspective.

Prior provides a thought experiment to illustrate the difficulty special relativity raises for presentism and then goes on to explain that difficulties in picking out an absolute present should not lead us to question the viability of presentism. Suppose, he suggests, that we observe the pulsing of a distant object in space, say the brightness of a star. As we observe these pulses, we ask whether each one is a present pulse or a past one because, while it appears present to us, it might well be long past for that distant object. While it is at first apparent that there is a clear distinction between past, present, and future pulses, special relativity leaves us doubting the ease and even possibility of making such distinctions.

If the distant body is having its n th pulsation as we perceive it having its $n-1$ th—*is* pulsating, and not merely has been or will be pulsating—then the n th pulsation and the perception of the $n-1$ th are simultaneous; not just simultaneous from such and such a point of view or in such and such a frame of reference, but simultaneous. And according to the special theory of relativity, such “absolute” simultaneity is in many cases just not to be had (Prior 2008, 382).

Prior suggests that the first and unfashionable response to this difficulty is to reply that the only difficulty physics raises is an epistemic one. That we do not, and perhaps never could, *know* what the absolute simultaneous present includes is a limitation on us, but not a direct denial that such a present does in fact exist. He goes on to suggest that there may well be other similarly intelligible questions that we simply have no means of answering (Prior 2008, 382). When it comes to physics and attempts to arrive at a universe-wide present, there is no difficulty for presentism in claiming that an absolute present exists. All presentism must acknowledge is that we do not and may never have epistemic access to that ‘now.’ However, Prior’s claim has not proven as simple or

obviously defensible as his article might lead us to believe and he acknowledges that it is not a particularly popular response.⁴⁰

By favoring the response that the problem is an epistemic issue regarding change and our limited perspectives, Prior seems to deny special relativity's claim that *an objective fact about the world is that simultaneity is relative to perspective*. Prior explains that he finds his response compelling because the present is a changing thing—much of what is, is constantly changing. Therefore, the real today is not necessarily the real tomorrow. Prior notes that though we may not always *know* what is present, given limitations on our powers of perception, our epistemic limitations have no bearing on the status of the real and the present (Prior 2008, 382). Prior supposes that the conflict between relativity theory and presentism is resolved by merely acknowledging that *our own* perspectives are limited, rather than requiring us to accept that there is no universe-wide, simultaneous present. Prior's response requires us to view special relativity not as a theory about the nature of space-time, but as a kind of 'phenomenological' theory about how we perceive space-time, and what we can observe about it. This response leaves many philosophers and physicists unsatisfied and we will return to it at a later point.

Prior goes on to observe that scientific practice gets around these epistemic limitations by developing language that does not permit our asking certain sorts of unanswerable questions (Prior 2008, 382-383). Because of these different questions, Prior suggests that metaphysical questions about what counts as real and when it counts as real do not much matter to a scientist and so the scientist modifies language so that those distinctions do not show in her work (Prior 2008, 383). Time is a slave to physics,

⁴⁰I largely omit discussions about the viability of Prior's kind of response, though I have and will continue to allude to some of those difficulties as I discuss relativity and the shifts required between kinds of conversations.

rather than a thing that physics attempts to carefully study. But part of Prior's interpretation of how scientists deal with questions about time comes from his failure to fully appreciate the changing parameters of physics—more on this issue later.

What makes this particular article of Prior's interesting and odd is that it provides a specific example of a rather widespread practice, that is, the use of specific lenses in our accounts of time. In this article, Prior makes an odd and somewhat ill fitting shift between two lenses. He begins looking at time with respect to tense-logic and ends by looking at time with respect to physics. I suggest that we can clarify both the oddness of this shift as well as the ill fit of it by interpreting it through the lens of time as a measure.

IV.2.iii. A Case in Point: Interpreting Prior

Prior's article provides us an apt case in point to my claim that understanding time as a measure of change allows us to better appreciate how diverging accounts of time relate to one another. Prior attempts to make two kinds of conversations, focused on two quite different aspects of change, intersect, but ends up giving us a deeply divided article instead of a unified one. The first conversation wears the lens of tense-logic, while the second shifts to a lens of special relativity. Prior does not fully appreciate this shift. I am not arguing that these two conversations, one about time in physics and the other about time in metaphysics, do not overlap, but that to make these conversations overlap well requires far more attention to the starting assumptions of each.

Prior's response to physics and special relativity reveals this ill-fitting shift in lenses. His first response is an epistemic one aimed at addressing the difficulties he sees in finding a simultaneous present that is universal. And so he responds that perhaps we cannot find the absolute now, but that failure reflects our limitations, not reality (Prior

2008, 382). This response does not fully appreciate the metaphysical difficulties that arise from simultaneity. In relativity, it is not simply that we are not able to access an objective ‘now’, but that the relativity of simultaneity is defined by what we *cannot* measure. The very possibility that simultaneity might be ‘relative to an observer’ really arises from the fact that causal signals cannot travel faster than light, and therefore observers cannot make ‘direct measurements’ (via causal interaction) of events that are sufficiently far away, and sufficiently close ‘in time’ to their ‘present’, since doing so would require a causal signal that propagates faster than the speed of light. Time turns into a space-time framework because we are not measuring some real thing called time. Rather, we are using a constructed framework to measure events. Einstein makes this point when he notes,

If we wish to describe the *motion* of a material point, we give the values of its coordinates as functions of time. Now we must bear carefully in mind that a mathematical description of this kind has no physical meaning unless we are quite clear as to what we understand by “time.” We have to take into account that all our judgments in which time plays a part are always judgments of simultaneous events (Einstein 1905, 2. Author’s emphases).

Prior does not recognize that relativity is not simply saying that we cannot find the absolute, simultaneous now, but that simultaneity and the ‘now’ are *defined by* our ability to measure events. For Einstein, measurement of duration ultimately depends on judgments of the form “the event that began the process was simultaneous with the second-hand of the clock pointing to ‘8’ and the event that ended the process was simultaneous with the second-hand of the clock pointing to ‘14’, and so the process took 6 seconds.” *What is means* for a given amount of time to elapse is reduced to observations of certain coincidences (‘the process began coincidentally with the second-

hand pointing to the ‘8’...). Einstein goes on to solidify this definition of time with an example,

But it is not possible without further assumption to compare in respect of time, an event at A with an event at B. We have so far defined only an “A time” and a “B time.” We have not defined a common “time” for A and B, for the latter cannot be defined at all unless we establish *by definition* that the “time” required by light to travel from A to B equals the “time” it requires to travel from B to A (Einstein 1905, 3. Author’s emphases).

While this passage and others like it may not give us a definitive critique of presentism, despite the hopes and fears of many theorists, it is certainly a discussion of time, simultaneity, and ‘now’ that relies on quite a different set of assumptions and definitions than most presentists adopt. We have both mathematical and physical assumptions as well as metaphysical ones that must be carefully articulated if we are to have a serious conversation between presentism and relativity. If a physicist says that time and simultaneity are *defined as the measurement of events*, then every metaphysician who wants to interact with those physical accounts of time has to properly appreciate the technical definitions being used. Otherwise, we run the risk of solving difficulties that are not real and missing the difficulties that are quite real.

Sean Carroll likewise discusses the role of time in physical theories, noting that:

Einstein's general relativity removes time from its absolute Newtonian moorings, but it continues to play an unambiguous role; time is a coordinate on four-dimensional spacetime, and in another guise it measures the spacetime interval traversed by objects moving slower than light. Quantum mechanics, meanwhile, takes things we formerly considered fundamental, like the position and momentum of a particle, and turns them into mere “observables” that imperfectly reflect the reality of the underlying quantum state. It is therefore perfectly natural to imagine that, in a full theory of quantized gravity, spacetime itself would emerge as an approximation to something deeper (Carroll 2008, 2).

In general relativity, time has two distinct roles. The first role of time is as a single coordinate in a coordinate system. The second role of time is as the length of the ‘space-

time path', that is, the path of a particle moving slower than the speed of light. The length is called the 'interval' of the path and the path is a continuous series of 'events' where each event has three spatial coordinates and one temporal coordinates. In the end, we arrive at a representation for the *motion* of a particle through space-time; a path through space-time represents the motion of a particle through space. That physicists use time to study changes in positions of particles is, on my account, to be expected. Moreover, it is not particularly surprising that time begins to look quite different than what metaphysicians imagine, given the quite different use that physicists are making of it.

The second response that Prior gives is that physics is not actually interested in asking about the present and so shifts its language around such that it does not need to deal with these sorts of questions. This second response offers both an affirmation of my interpretative account and also an incomplete recognition of the differences between these varied uses of time. He begins this second response with this contention:

Furthermore, when confronted with unanswerable questions, it is often good scientific practice to devise a language in which these questions cannot be even asked. And this usually involves a good deal more than just refraining from admitting certain words or longer expressions into one's scientific vocabulary; the very syntax of scientific language will be involved too (Prior 2008, 382).

Prior is at once recognizing the lens shift occurring amongst scientists and at the same time, failing to fully understand it and correctly explain it. Scientists may sometimes actively avoid certain unanswerable questions. However, the primary reason they do not address those questions, if the account in this paper is correct, is not due to an active choice to avoid, but rather, to the differences in starting lenses which do not admit of certain kinds of questions. The language changes are not because physicists want to

avoid certain questions, but because the lenses they bring to the table of physics are aimed at answering other sorts of questions. They are using time to consider and describe different things from those for which metaphysicians use time. Even Prior seems to half realize this difference in parameters when he suggests that it is “good scientific practice” to avoid certain questions and at the same time he misses the importance of that realization when he accuses scientists of “devis[ing] language” to avoid unanswerable questions. However, Prior misses that these “unanswerable questions” are unanswerable precisely because they are not native to conversations in physics—they are questions that do not show up in the conversation *because* the physicist is wearing a different lens and setting different parameters in order to consider different aspects of change and answer other kinds of questions.

In contrast, Prior is interested in a different kind of change in his use of time. His article begins with a tense-logic account of the present and elsewhere he addresses more thoroughly the kind of ‘now’ and change in which he is interested. One of Prior’s primary concerns is to capture, with language, truths about the changing world (Copeland, 2017). As he observes, “certainly there are unchanging truths, but there are changing truths also, and it is a pity if logic ignores these, and leaves it ... to comparatively informal ‘dialecticians’ to study the more ‘dynamic’ aspects of reality” (Prior 1996, 46).⁴¹ Prior aims to use the language of tense logic to capture changing truth (Copeland 2017).

⁴¹Prior’s tense-logic aims to capture, with language, what is always true and what is only sometimes true, the change in what is true about the world around us and about the words we use. Again, elsewhere we find Prior struggling with this project:

Changes do change, then, but this does not leave everything quite simple and solved. For there’s still something odd about the change that we describe figuratively as the slow passage of time—the change from an event’s being future to its being present, and from its being present to its being more and more past. For the other changes in events which I have mentioned are ones which go on in the event

On the account of time that I offer, we are able to preserve what is worth preserving in a theory like Prior's without accepting all of his theory. After all, there is something right in Prior's view, for example that our language is sloppy and repetitive. Eliminating the redundancy helps the clarity of our communication and our thinking. However, we are also free to recognize where Prior has failed to sufficiently recognize how physical accounts are using time.⁴²

When we bear in mind the different starting points and uses of time, we can recognize that it would be as odd for a physicist to be upset that a tense-logician had not defined the present in terms of space-time or the cycles of cesium atoms as it is for a metaphysician to be annoyed that a physicist does not address ontological questions of coming to be and passing away. Bridging the gap, if it can be done, between various kinds of conversations about time, physical and metaphysical, takes a good deal of attention to framing assumptions and background theories.⁴³ If we embrace the account of time as a measure of change, then in addition to expecting these disconnected conversations, we might also expect that participants within the various discussion will begin to see and cast their discussions as more properly about some specific aspect of change.

while it is occurring; for example, if a lecture gets duller or a movement faster then this is something it does *as it goes on*; but the change from past to still further past isn't one that occurs while the even is occurring, for all the time that an event is occurring it isn't past but present, in fact the presentness of an event just is its happening, its occurring, as opposed to its merely having happened or being merely about to happen (Prior 1968, 9).

⁴² While other presentists give longer and more developed attempts at carefully moving between physical and metaphysical accounts of time (See Zimmerman 2013 and Crisp 2003), as we will see in the next case study, we will still find that their attempts do not sufficiently account for the background assumptions and parameters implied by the terms that they borrow from physics.

⁴³ Note, for now, I assume that these conversations are *about time* (in the next case study and the conclusion, I will question whether they are).

IV.2.iv. Conclusion

I have argued in this paper that viewing time as nothing more than a measure of change, rather than as a real thing itself, can provide a unique framework for reconciling the various conversations we see occurring in theories of time. As we develop our understanding of the observer's role in defining and constructing measurement outcomes we also come to a better understanding of what it might mean to call time a tool. We can account for the varied, and often diverging, discussions about time as the natural result of employing time to measure the different aspects of change in which we are interested. We find this divergence precisely because we are *using* time, not studying it.

With this account of time, we are also better able to understand the kind of work that we would need to do if we want to compare these diverging conversations. Looking at Prior's article, we see an example of diverging conversations about time and are able to understand why the article is odd—Prior attempts to relate two very different kinds of accounts of time without fully appreciating the background assumptions that belong to each. To relate these conversations to each other, one would have to remain scrupulously aware of the starting lenses that each conversation presupposes from the outset and, from there, work to find what common ground might exist. This is a challenge that Prior shares with fellow presentists and metaphysicians.

IV.3. Measuring the Present

Presentists argue that only the present is real, the past and future are unreal by comparison. They assert time and again that the present is a privileged time—a moment unlike any other. In this paper, I explore how presentists might define the present, 'now,'

with respect to the question, “does the present moment have duration?” To this duration question, I consider three different “no” responses, one “yes” response, and some of the implications raised by each of those answers. Two issues are at stake here, 1) how the ‘now’ is defined and 2) whether the ‘now’ has duration. A sufficiently thorough definition of the ‘now’ will also provide an answer to the question of duration. Therefore, where we find ourselves unable to answer questions about the duration of the present, we also have reason to worry that the definition of the present provided by presentists is not as comprehensive as needed.

The first section of this case study begins with a look at how presentists define the present moment and the second section raises questions about the duration of that moment. I conclude that some of the more troublesome questions about duration can be avoided, provided we no longer count presentism as a theory *about time*.

IV.3.i. Defining the Now

Because presentists spend little time trying to define the now there is some ambiguity about what exactly they think it is. However, as we explore their accounts more, there are some positive indications of what they imagine the present moment to be and this section is devoted to understanding the terms and definitions that are provided.

Thomas Crisp is one of the few presentists who provides some definition for the now and he defines it as a maximal slim object. While there are plenty of questions to ask about what this maximal slim object, a term to be further defined, might be it seems consistent with other presentists like Dean Zimmerman and A.N. Prior, who, as well as Crisp, argue for a universal instant or a privileged foliation of the universe, also terms to be further defined. The standard interpretation of relativity theory is that it denies a

privileged foliation (where a privileged foliation is the division of a 4-dimensional space-time into a series of 3-dimensional spatial slices, each one representing the state of our spatially 3-dimensional world at an instant). Presentists take this standard interpretation as a threat to their position (Crisp 2003, 233). Judging by presentists' responses, they appear to understand their position as one that can be framed in the same terms, using the same concepts, as those employed in this standard interpretation of relativity. It seems then, that they take themselves to be talking about 'physical time'. In attempting to defend presentism from challenges from relativity theory, presentists borrow many terms, like 'instant' and 'privileged foliations', to help define the present and, in doing so, paint a picture of the 'now' as a physical instant.

In the early part of his article, Crisp takes a moment to define the present. We should understand the presentist's proposition, "(Pr) For every x , x is present," to mean three things: first, that "where an object x is present iff x occupies or exists at the present time" (Crisp 2003, 212); second,

...we shall think of *the present time* as follows. Say that an object x is *slim* iff, for any y and z , if y and z are parts of x , then there is either no temporal distance or a temporal distance of *zero* between y and z . A *time*, let us say, is a maximal slim object: an object such that the mereological sum of it and anything which isn't part of it is not slim. The present time, intuitively, is the maximal slim object that includes as a part every event that occurs *now* (Crisp 2003, 212).

And third, we understand that proposition to "say that something *exists at* or *occupies* the present time iff it is a part of the present time" (Crisp 2003, 212). From here Crisp moves on to consider and defend the proposition (Pr) as neither trivially true nor manifestly false (Crisp 2003, 212).

The above paragraph is as much detail as Crisp provides with respect to defining the *now* or this "maximal slim object." With his talk of mereological sums, temporal

distances of zero, and distinctions between times, Crisp partly answers the question of duration by suggesting that the now either has no duration or a duration of zero. And there is reason to suppose that, while less overt, other presentists imagine the ‘now’ in a way that is consistent with Crisp’s definition. In his response to the usual interpretation of relativity theory, Crisp goes on to talk about a universal instant that is the present moment (Crisp 2003, 234-235). With his use of terms like ‘instant’ as well as his brief definition of the now, Crisp is explicitly bringing up the question of duration and offers two answers, i.e. no duration or duration zero, without endorsing either.

The remainder of his article is devoted to defending presentism against relativity theory and defending an abstract, relationalist account of time where

time is past or future for us when it bears the *temporal* accessibility relation to our time. If we take this relation to carry a direction, we can say that a time is past when it is *backwardly* temporally accessible and future when it is *forwardly* temporally accessible. More simply we can say that a time is past when it is *earlier than* the present time and future when it is *later than* the present time. [so we can call] a philosopher who believes in such abstract times and an earlier-later relation linking them an *abstract time realist* (Crisp 2003, 241; author’s emphases).

However, because Crisp does not elaborate further on his early definition, Crisp’s account is not comprehensive enough to provide a satisfactory answer to the question of duration. Therefore, I will move to another presentist’s account, Dean Zimmerman, to continue filling out a definition of the present and sketching an answer to the question of duration.

Dean Zimmerman endorses Putnam’s summary of presentism as a view of time that belongs to “The man on the streets”. This view amounts to the view that:

All (and only) things that exist *now* are real”—and [...] by “real”, we ordinary people-in-the-street do not mean something merely relative, so that what is real-to-me might not be real-to-you: we mean to be talking about a transitive,

symmetric, and reflexive equivalence relation, one that holds between events currently happening to us and at least some other events happening elsewhere, to other things—including events happening to things in motion relative to us (Zimmerman 2013, 206).⁴⁴

Zimmerman goes on to argue for a substantialist version of relativity and in favor of a privileged foliation (Zimmerman 2013, 204-205). A foliation is an exhaustive collection of instantaneous slices of the state of the universe at a given time. In general relativity, there may not be any slices, and on a usual interpretation of special relativity there is no privileged slice. On a usual interpretation of special relativity, there is no privileged foliation because which events count as simultaneous to each other—or for the presentist, the events that are happening now—depend on the perspective from which one takes a ‘slice’ of the universe.

Zimmerman notes, that while there are many potential and unusual shapes of the universe, the presentist expects and even needs, “a manifold with a time-like direction to have a privileged foliation—a division of the manifold into slices each of which contains events that [are] all happening at once” (Zimmerman 2013, 188). Zimmerman’s reference to the present as a privileged foliation suggests that, like Crisp, he may have in mind a moment with no duration or zero duration. While Zimmerman might think that the present has no duration, that is, that the concept of duration does not apply to the present, it does not seem likely, given his reliance on terms borrowed from physics—terms to which the concept of duration does apply (for example, in special relativity, the temporal ‘size’ of a slice is measurable and it has measure 0).

⁴⁴ Zimmerman goes on to mark Putnam’s eventual conclusion that Presentism is inconsistent with special relativity theory and address further misunderstanding with respect to both Putnam’s argument and Presentism (206). Moreover, while it is commonly taken as a strength of Presentism that it is the “people-in-the-street’s” ordinary understanding of time and reality, it is not clear either that it *is* an ordinary view of time or that ‘ordinariness’ should count as evidence for the correctness of a view.

Given the use of these sorts of terms, we might ask what duration the present has? ‘Instant,’ ‘slice,’ ‘maximal slim object’, for example, are terms that seem to suggest that it has a duration of zero. Still, whatever answer presentists give to the question of duration, there are interesting implications and the next section is devoted entirely to exploring those implications. Before that exploration it is worth noting one more presentist who considers questions about measuring time.

Ted Markosian considers the passage of time and we might think that in doing so he considers duration. Markosian defends presentism’s ‘passage of time’ against a worry about the need for layers of time-dimensions by which to measure normal time (Markosian 1993, 838). Markosian sees the threat of an infinite regress of ‘super-times’, as I will call them, as fundamentally rooted in questions about change and whether we are actually measuring a ‘pure passage of time’ or merely a conventional ‘time’ that is nothing more than compared rates of change (Markosian 1993, 839-842). Markosian concludes that while it is possible that the passage of time is really just about comparing rates of change, it is also plausible to suppose a ‘pure time’ and to compare the ‘passage of pure time’ to itself such that we can sensibly say that “time passes at a rate of one hour per hour” (Markosian 1993, 843). Therefore, he argues, “the passage of time is a change whose rate may be measured with respect to itself, so that there is no need for me to posit any second time-dimension with respect to which the passage of normal time is to be measured.” To ask about the rate of the passage of time is to make a category mistake because “the answer would have to involve a comparison between the pure passage of time and the pure passage of time, but such an answer would not make sense because the

pure passage of time has a unique status among changes—it is the one to which other, normal changes are to be compared” (Markosian 1993, 843).

We might wonder how we are to compare “normal changes” to an inaccessible “pure time” and we might think that Markosian is himself making a category mistake by calling time a change. Regardless, Markosian is asking “how fast does time pass?” and he sees two answers. First, that this question only makes sense as a comparative one, that is, what is the rate of process A when compared to process B. Second, that this question makes sense in an absolute sense, as a question about time itself—and the answer is, “time passes at a rate of one second per second.”

However, Markosian does not address another sort of issue—an issue about duration. For infinitesimal instants that measure zero stretches of time to be integrable into a finite-duration ‘collection’ of instants, we would have to appeal to an *additional* measure that tells us how instants compose to generate finite stretches of time. If we say that each instant has a duration that measures zero, we leave *indeterminate* what the duration of any (continuous) collection of them will be. A continuous collection of instants only have a well-defined duration in reference to the choice of measure; but then the measure would seem to be another sort of time, one whose nature is not explained by the mere composition of instants. So, it turns out, Markosian is not helpful in our current conversation about duration.

IV.3.ii. Duration of the Now

Either the present moment has duration or it does not. Several interesting implications arise from attempts to answer yes or no to the question, “does the now have duration?”. There are at least three sorts of no answers and one yes answer that we might give. But first a note on measurement.

We define a measure on the ‘set of all measurable subsets’ of some set. We commonly look for a measure that tells us the size of a subset of our set and for countable sets, the size is always defined.⁴⁵ A measure, m , on a set, S , is a function that assigns a non-negative real number to subsets of S . Certain requirements are placed on and measure, m .

- (i) $m(E) \geq 0$ for all subsets, E , in the domain of m .
- (ii) $m(\emptyset) = 0$. (The measure of the empty set is zero.)
- (iii) Let E_1, E_2, \dots be a countable collection of disjoint subsets of S . Then the measure of their union is the sum of their individual measures, i.e.,

$$m(E_1 \cup E_2 \cup \dots) = \sum_{n=1}^{\infty} m(E_n)$$

The reference to ‘the domain of m ’ above is necessary because, in general, it is not possible to define a measure that has every subset of S in its domain – the measure will

⁴⁵ Subsets of continuous sets, such as real numbers, prove challenging to measure because the set itself is uncountable. Consequently, since our measure does not always result in a defined size, when we try to measure these sorts of sets, we have to spend more time defining what will count as a sufficient measure. Defining our measure more carefully requires that we develop a list of properties that we want a measure to satisfy, but which properties should make it on the list is not obvious. We will have to include definitions for what counts as equal and equivalent sets, such as a one-to-one correspondence, as well as long list of other properties about which we may care for a variety of reasons (Partee, Muelen, and Wall 1990, 8 and 55-70).

simply be undefined for some subsets of S . We call the subsets of S for which m is defined the ‘ m -measurable subsets’ (Tao 2011, 3). We call ‘ m ’ a ‘measure on S ’, but this is really shorthand for ‘a measure on an appropriately chosen collection of subsets of S ’. There are many measures on the real line, \mathbf{R} , (uncountably many of them, in fact) that have the following property:

$$m(\{x\}) = 0$$

for all $x \in \mathbf{R}$. By saying that there are ‘many’ such measures, what we mean is that any two such measures could disagree about the measure (e.g. duration) of some finite interval.⁴⁶ That is, there are measures, m and m^* , for which

$$m(\{x\}) = m^*(\{x\}) = 0 \text{ for all } x \in \mathbf{R}$$

but for some points, a and b ,

$$m([a,b]) \neq m^*([a,b])$$

In other words, the presentist account of time cannot simply be that intervals (‘durations’) are composed of measure-zero instants, because this account leaves indeterminate the actual duration of any given interval of time. Presentists could deny this claim and argue that time is simply the mereological sum of the instants, but that there are temporal distance relations.⁴⁷ While some might find this sort of reductionist account acceptable, others might be concerned with this response for at least the following reason relations.⁴⁸ One concern might be that this response leaves time in the odd position of having a fundamental property (duration) that is disconnected from its fundamental

⁴⁶By a ‘finite interval’ is meant a set of real numbers of the form: $\{x \mid x > a \text{ and } x < b\}$. We write a finite interval as (a,b) . The less-than and greater-than signs can also be less-than-or-equal-to (and similarly for greater than), in which case we would write one of the following: $[a,b)$, $(a,b]$, or $[a,b]$. (‘[’ and ‘]’ indicate “or equal to”).

⁴⁷Thanks to Alexander Pruss for suggesting this option as a possible presentist response.

⁴⁸Thanks to Michael Dickson for offering this concern that one might have with this response.

constituent instants, which are mereologically composed. We could end up with instants which measure zero individually but add to something greater than zero (assuming that we think events typically have a non-zero duration; van Bendegem 2014) and it seems, at the very least, an odd sort of addition that allows us to add a pile of zeros to a non-zero result. I leave it to the presentists to decide whether they find this sort of account satisfying or these worries sufficient to deter them from adopting it. What is interesting in this potential response, as with the others that I will raise below, is not whether they should adopt *it*, but that they need to adopt *some account*. If they prefer a more traditional measure here are several options.

Suppose we consider some interval of time, $[a,b]$, “the time from a to b”. What is the presentist’s account of the duration of that interval? We have already set aside the response that the interval has its duration in virtue of being composed of the instants from a to b, because composing those instants leaves the duration indeterminate. So something else is determining the duration, and on a realist account, it would seem that that something else must be ‘how much time has passed between a and b’, which leaves us right back where we started.

A presentist might respond that the duration of finite intervals is not indeterminate on her account because the Lebesgue measure is the only translation-invariant measure on the real line.⁴⁹ So, if presentists adopt the principle that durations are translation-invariant, then durations are not indeterminate.

⁴⁹ The Lebesgue measure is confined to real numbers and provides the intuitive result that the measure of an interval $[a,b]$ is size $b-a$. For example, where we let $m()$ be a Lebesgue measure, $m([2,4])=2$. Adopting this measure brings with it its own set of additional complications, for example: as soon as we include the properties of the Lebesgue measure, we find that for any single point, r , on the real line, $m(\{r\})=0$. Moreover, by countable additivity, for any collection of countable points, r_1, r_2, r_3, \dots , $m(r_1, r_2, r_3, \dots)=0$. But because countable additivity does not apply to uncountable sets of points, it can be the case that all countable sets of points have measure zero while all uncountable sets have a finite measure (Tao

While the presentist response is true, it does not resolve the argument in her favor. The response above is at best a realist account of ‘instants’, but presentists want a realist account of time. A presentist’s motivation of the Lebesgue measure appeals not to properties of instants, but to properties of time as a whole. But time is not merely a simple ‘collection of instants’; it has properties (and thus durations have properties) that are not determined by the properties of instants. So ‘durations’ are what they are because ‘time as a whole’ is what it is, and not because ‘instants’ are what they are. But then what is this ‘time as a whole’? What is their account of it? What is the ‘super-time’ that is above and beyond the mere collection of instants (3-dimensional spatial slices of 4-dimensional spacetime) to which presentists like to refer?

To the question of duration, there are a variety of answers a Presentist might want to give (some already hinted at).

If a presentist answers no—that the present moment does not have duration—then that might mean one of at least two things. By this first “no” answer, a presentists might mean that the concept of duration does not apply to time. In which case, he means that an instant has no duration because there is no number, not even zero, that applies to an instant.⁵⁰ It would be difficult to explain how these instants could amount to any duration, certainly not by an aggregation of instants, since we seem to have nothing from which to derive the duration. However, Crisp and Zimmerman seem to think that duration is an applicable concept (Crisp by an explicit attempt to define duration and

2011, 23). See Terence Tao’s (2011) for a closer look at defining the Lebesgue’s measure, both inner and outer measures (section 1.2) and Lebesgue integrals (section 1.3).

⁵⁰ Some presentists worry that a duration of zero seems to create a sharp divide between what exists and what does not exist and, therefore, raises further worries about how to account for things with partial being—such as things *coming into being* (Ford 1974, 101).

Zimmerman by entering into conversations in physics with established uses of terms like ‘instant’).

On the other hand, the second “no” answer we might give is that each instant has duration 0, and there are uncountably many instants. But then the Lebesgue measure is applicable here and the issues raised earlier come into play.

Finally, a presentist might respond, “yes, the present moment does have duration.” Perhaps presentists will want to say that each instant is non-zero and there are countably many instants. Here the Lebesgue measure does not apply because it is a measure on the real line, and, in this case, the likely measure to adopt would be the integers. There is nothing wrong with adopting a discretist account of duration but it is important to notice, as I will in further detail in a moment, that it assumes a measure rather than defining a measure. Assumed or defined, we must adopt some measure to define that duration. So, we still have a need for a super-time by which to measure the duration of the present moment.

It might seem that being a realist about time avoids some of the constructivists’ worries about measurement; it does not, as the above discussion shows. It is the need to adopt a measure, not which measure is adopted, that leads to the problem of a super-time. A realist response, whether as a finitist or infinitist, will face the same need to adopt a measure. To fill out what I mean, I return to two options from earlier. Suppose that presentists are realist about time, as it seems they are, and so define time as the set of all instances, isomorphic to the set of real numbers. Then we can take any interval we like, such as $(0,1)$ and ask, “how long is the interval?” To answer our question, a measure, of the kinds discussed or of some other kind, must be adopted. Then again, presentists

might opt to define time as a set of all instances isomorphic to the set of integers. Here again we can take a collection of integers, such as $\{0,1, 2,\dots, 100\}$, and ask, “How long is the collection?” The answer is something like: “length(0) +length(1) + length (2)+...,” an answer that requires the adoption of a measure to define our ‘length.’

If we adopt a measure, however, it seems we have appealed to a ‘super-time’ by which to measure our particular infinitesimal moments. The point is not what measure we adopt or what conventional quality our measures may or may not have, but *that* some measure is being adopted. The adoption of a measure is problematic for the presentist because, at the very least, it commits her to a super-time by which to get the finite intervals ‘right’. If the presentist finds herself in need of a super-time to measure the present, it seems that the problems for presentism have merely been deferred a level.

IV.3.iii. A Conclusion that Helps Presentists Out

One solution to the problems of duration for presentists is to adopt a view of time as nothing more than a measure of change. Tools are adaptable to the context in which they are used and can be repurposed for use in new contexts (Tal 2011, Knuunnttila 2011). Not only do we adapt tools, but doing so is justified by our epistemology of measurement (Tal 2016, van Fraassen 2012).⁵¹ Tools are constructed within particular theoretical frameworks and aimed at measuring the things that are defined by our theoretical framework. In a given project of measurement, the very parameters that define which tools count as sufficiently adept tools in *this* project are set by the very theories that the project aims to test, as well as a variety of other considerations, such as social and political factors (Tal 2016). Things like the success, calibration, and parameters of any

⁵¹ Bas van Fraassen (2012) argues that we must do careful work in defining and articulating the parameters of our measurement.

given tool are necessarily derivative on whichever broader constraints and theories are adopted—without which we have no means of judging the purpose or performance of any given tool. As Bas van Fraassen argues, “not only what a procedure measures, if it is a measurement procedure, but whether it is a measurement in the first place is a question whose answer is in general determined by theory, not solely by operational or empirical characteristics” (van Fraassen 2012, 782). We ought not imagine the measurement can occur independent of theory, for it is necessary that our theories mold our measurements. The realities of measurement practice and the reasons for them provide reassurance to us that our habit of adapting tools to particular uses is both expected and justified.

If Presentists understand time as a constructed tool for measuring various aspects of change, then they can define the present in a way that suits their purposes. For example, they can claim that the present moment is characterized by a lack of potential for change, and thus should have a duration of zero. Notice, this definition of the ‘now’, set within the view of time as a measure, avoids the first concern about duration. The first concern is that to understand how durations can aggregate we need to adopt a temporal measure, which amounts to adopting a ‘super-time’. But this concern is now avoided because there is no pretense that time is a ‘thing’ that is somehow mereologically composed of instants. This alternative account of time allows presentists to largely avoid doing certain sorts of work, such as resolving problems of duration. Presentists are free to adapt time in service of their primary aim of distinguishing between the existing and non-existing. The alternative account already does the work of justifying the omission of certain sorts of questions that presentists have not sufficiently answered, such as “what is the duration of the now?”.

However, there is a cost to the presentist. Presentism is now no longer a theory *about time* (if it ever was).⁵² It is not too high a price to pay for avoiding the problems of duration that still need addressing before we can count presentism a robust theory *about time*. If presentists want their theory to be about time, then they will most likely need to answer questions like the question of duration that I raise in this paper. There are other questions that we may also expect an account of time to engage, such as about discrete and continuous time. As already noted, it is not clear that these sorts of questions need answering for an account *about existence*, though they do for an account *about time*.

Outside of how presentists cast and categorize themselves and their theory, it seems that adopting this alternative account of time still leaves them free to continue their discussions about questions of existence and what counts as real. There will be new difficulties in picking out what counts as existing, since the ‘now’ no longer does that defining work. Moreover, presentists may find that their concerns have more to do with things like shared reality, lack of causal access to the past, and so on. Even still, presentists will not need to stop using their temporal terms. Temporal terms, understood from within an account of time as a measure, are useful just because they can be adapted to the needs of the particular conversation about particular aspects of change. Moreover, the adaptations and manipulations that time undergoes, to be useful to the presentist, is justified; such adaptations are legitimate and expected ways of altering and re-defining the tool, time, to the particular context (Tal 2016, Boesch 2017).

⁵² Daniel Deasy (2017) suggests that presentism is properly about questions of existence.

Chapter V: What Happened to Time?

Is presentism a theory *about* time? Daniel Deasy argues that we ought to recast presentists' theories as attempts to answer questions of coming into existence and passing out of existence (2017). In response, Jonathan Tallant argues that Deasy has mischaracterized presentism and that, even if Deasy's characterization were accurate, Deasy's main point is wrong—that is, presentism *is* properly a theory about time (Tallant, 2017). The debate between Deasy and Tallant is interesting in that it raises two separate but related questions. First, is presentism a theory about time? Second, what counts as a theory of time; that is, what sorts of considerations and questions should a theory of time be able to address?

In section one, I give a brief review of Deasy and Tallant's debate over the first question. In section two, I argue that Tallant, in his attempt to defend presentism as a theory about time, instead, uses time as a measure—past, present, future—to discuss what things exist but does not end up providing a theory of time. Although I argue that Tallant has not yet shown that presentism is a theory about time, I refrain from speculating whether a successful defense can be mounted. Until or if a successful defense of presentism as a theory of time is given, presentists are in need of a theory of time. Here we arrive at the second question: if presentism is not a theory about time, then what counts as a theory of time?

I do not aim to give a complete answer to the second question so much as raise it. However, I do give one example of a theory that counts as a theory about time. In the third section, I sketch a theory where time is nothing more than a measure of change. This sketch provides both a starting place for answering the question, “what counts as a theory of time?” and a theory that presentists might find helpful. Presentists may find themselves surprised by the convenience of this theory because it carries with it relatively few metaphysical commitments about questions of existence, proves itself quite adaptable to the needs of various theories, and leaves ample space for quite a wide range of positions in the realist versus anti-realist debates. The sketch of time that I offer has the added appeal of being able to explain why presentists find their questions of existence drifting from being about time to about the existence of other things.

V.1. The Debate: Is Presentism a Theory about Time?

What is most interesting about Deasy’s article is not Deasy’s characterization of presentism, which is inadequate on many levels, but is Deasy’s challenge that presentism is a theory about questions of existence, not time (Tallant 2017,). For his part, Tallant aims to defend presentism as a theory that asks existence questions about time.

V.1.i. Deasy: Presentism is not a theory about time!

Deasy argues that shifting the conversation towards questions of existence not only captures what presentists are after but also provides substantive ground for discussion and means of progress (Deasy 2017). Presentism and other A-theories are best understood as concerned with questions about existence—that is, “do things begin to exist?” and “do things cease to exist?” (Deasy 2017, 22, 27). The traditional characterization of

Most growing blockers, on the other hand, appear to answer ‘yes’ to (i) and ‘no’ to (ii): they hold that as time passes, many things—such as cats, cars, trees, and stars—begin to exist, but never cease to exist (once they begin to exist, they form an eternal part of the expanding block universe.[...] ⁵⁴

Finally, most moving spotlights answer ‘no’ to both (i) and (ii): they hold that existence has neither a beginning nor an end, and therefore the ontological facts are fixed for all time. ⁵⁵

These two questions about existence allow presentists to more easily and clearly understand and compare theories that have traditionally been categorized as about time. ⁵⁶

Deasy suggests that we re-categorize the above views as:

PRESENTISM: There is an absolute, objective present instant (THE A-THEORY) & sometimes, something begins to exist and sometimes, something ceases to exist (TRANSIENTISM)

THE GROWING BLOCK THEORY: There is an absolute, objective present instant (THE A-THEORY) & sometimes, something begins to exist and nothing ever ceases to exist (PASTISM)

THE MOVING SPOTLIGHT THEORY: There is an absolute, objective present instant (THE A-THEORY) & nothing ever begins to exist and nothing ever ceases to exist (PERMANENTISM) (Deasy 2017, 25).

Understanding A-theories in these terms preserves the distinction of A-theories as A-theories in standard temporal-logic terms, while also providing a clear explanation of the predicate ‘is present’ and ensuring that these theories remain theories with substantive implications for issues of ontology and change (Deasy 2017, 25-26).

⁵⁴Deasy goes on to argue that “growing blockers appear to be committed to the thesis of *pastism*, according to which sometimes, something begins to exist but nothing ever ceases to exist” (Deasy 2017, 23-24).

⁵⁵ Deasy further explains this claim with, “the thesis of permanentism [is that] always, everything always exists” (Deasy 2017, 24).

⁵⁶ Elsewhere Deasy categorizes the Moving Spotlight theory as a combination of “permanentism, the thesis that everything exists forever, and the A-theory, the thesis that there is an absolute, objective present time” (Deasy 2015, 2073).

V.1.ii. Tallant: Presentism is a theory about Time!

Tallant notes that quite apart from Deasy's iterations and critiques of presentism, there is an over arching challenge in Deasy's article, which is that current debates in presentism are mischaracterized (Tallant 2017).⁵⁷ Tallant defends presentism against this larger challenge by arguing that presentism is properly a theory about time.

Tallant notes that others such as Timothy Williamson also critique presentism for having “no good account of what it is to be present’ ([Williamson] 2013, 24). This is a metaphysical complaint. For presentism to be viable, we must hear much more about the metaphysics of what it is to be present (Tallant 2017, 14).” Tallant acknowledges Williamson's (and we might add, Deasy's) point that, “few presentists have much to say about the details of what it is to be present” (Tallant 2017, 14). And then, in response, adds that he wants “to pursue a view [...] that equates existence and presence (Tallant 2017, 14).” Already we might think that Tallant's choice to defend his account of time by offering a view about existence and presence is odd in that *time* instantly disappears from the picture. Tallant's responses appear to affirm, rather than undermined, Deasy's attempt to recast presentism. Although Tallant acknowledges that often presentism is not doing the work that we might expect of a metaphysical theory about time, at the same time, he does precisely what Deasy claims presentists will do—Tallant begins casting presentism in terms of existence. Again and again, Tallant acknowledges the challenge from Deasy (and in other places Williamson as well⁵⁸):

Now to be fair to Deasy, I do think that philosophers working in the philosophy of time have unduly focused their attention on the existence question. It is relatively

⁵⁷I bracket Tallant's critique of Deasy's iterations of presentism. The strength of Deasy's critique and re-characterization of presentist debates are not essential to the point I aim to make.

⁵⁸Again elsewhere, Tallant addresses Williamson's objection to presentism (Tallant 2017, 17).

unusual to see philosophers of time wondering about what it is to be present (for instance) given presentism—though Craig’s (1997) ‘Is Presentness a Property?’ is a very obvious outlier and there are a range of others invested in the project. It is far more usual to see debates about whether the presentist’s ontological commitments (their answers to the existence question) are defensible (Tallant 2017, 25).

At first it appears that Tallant has largely granted Deasy’s main point that presentists are talking about existence to the neglect of time; but then Tallant continues. To show that presentism is properly a metaphysical account about time, Tallant lays out his own account of presentism, which he refers to as ‘Existence Presentism’:

draw[ing] a distinction in *kind* between the position adopted by presentist (on the one hand) and eternalist (on the other). [...] I define (my preferred version of) presentism as the view that existence is presence, further clarifying the view by remarking that: ‘Presence is existence is an identity claim.’ (Tallant 2017, 15).

Tallant views this concept of existence as being Quinean/Lewisian and explains it by offering van Inwagen’s definition, “if existence is a property, it is the property something has if and only if it exists, if and only if there is such a thing as it” (van Inwagen 2008, 37). Tallant concludes then that “existence *is* the property of presence” and that “for no other view does an object qualify as present merely by existing (though it may qualify as *present at t*, for some value of *t*, but that is quite a different thing” (Tallant 2017, 15, author’s emphasis). Tallant’s points to Trenton Merricks and Dean Zimmerman as having similar accounts of presentism. Tallant quotes Merrick’s characterization of presentism as “I think presentists should [...] say that existing at the present time just is existing” (Merricks 2007, 105). And for Zimmerman’s presentism Tallant points to Zimmerman’s comments that “to be present *just is* to be real or to exist” (Zimmerman 1996, 117). Note that again time, that is, the present, is defined in terms of existence.

As Tallant works to defend presentism it grows increasingly obvious, in each response he gives, that time disappears from the conversation. Without seeming to notice that he has defined presentism in the very ways that lead Deasy to call presentism a theory about existence, Tallant turns to the larger question at hand, “is presentism a theory about time?”

Tallant objects to Deasy’s re-casting of presentists’ debates precisely on the grounds that Deasy’s re-casting means that these debates are no longer about time:

If we hold fixed my claim that existence is presence and that a ‘block’ of reality exists, then which of Deasy’s transientism or pastism turns out to be true turns on whether or not Existence Monism is true: pastism is true if Existence Monism is false; transientism looks to be true otherwise. That’s an interesting question to pursue, to be sure, and is certainly philosophically substantive. But it does not seem to be a debate between positions that are distinct with regards to their commitments qua theories of the nature of time. Since this is supposed to be a debate about time (or so I assume) so it looks like a misclassification (Tallant 2017, 20-21).

But that “misclassification” is just what is so interesting about this whole discussion between Deasy and Tallant. The re-classification that Deasy advocates is only a mistake if presentism is properly a theory about time; if presentism is properly a theory about existence, then it is the presentists and not Deasy who have misclassified presentism as a theory about time.

Tallant recognizes that the burden of proof rests with him to show that presentism is properly a philosophy of time. So he argues that the questions of existence that presentism raises are the more basic questions of “what exists?” full stop.

Deasy thinks that we should be asking (i) Do things begin to exist? (ii) Do things cease to exist? I have objected to the results of pursuing those questions. In contrast, then, since this is a debate about the metaphysics of time, I think that we should do metaphysics. And I think that engaging in the metaphysics of *x* (for all *x*) requires two things of us. It requires us to ask existence questions (‘what is there?’) and it requires us to ask kind questions (‘of those things that exist, *what*

kinds of entity are they?'). And I think this is the way that the philosophy of time *has* proceeded (Tallant 2017, 23, author's emphases).

Despite Tallant's protestations, it is telling that even his more basic questions about existence do not focus on time. We might expect that basic existence questions about time would begin with things like, "Does time exist?" Instead, as we see in the quote below, Tallant assumes time.

I do not think that Deasy is correct when he states that the traditional questions in the minds of those whose theories about time are: (i) are there past things? Are there future things? [...] I think that the traditional questions are—and have always been—what is there? And, how is it? (In the current context this second question amounts to 'what is it to fall under the predicate 'is present'? What metaphysical kind is 'presence'?) In short: first we ask our existence questions, then we ask our kind questions.

Presentists answer the existence question: only present things. Growing Block theorists answer: past things and present things. Eternalists answer: past, present and future things (and offer a reductive analysis of what it is to be past, present and future). (Tallant 2017, 23).

But to answer the existence question in this way, i.e. "only present things", is just to assume time rather than to ask the existence question about time. And elsewhere he also characterizes these questions as

We first answer the 'what is there?' question (only the past and present objects); we then answer the 'what is it to be past? What is it to be present?' questions: being present is existing at the last time in existence; being past is existing without existing at the last time in existence. Again: first we answer our existence question, then we ask our kind question (Tallant 2017, 25).

Tallant thinks that he has answered Deasy's challenge but Tallant's defense is notable in that he still does not focus on time. Tallant has not clarified the term "is present", rather he has acknowledged that it is rarely carefully considered by presentists and then proceeded to assert that presentism is a theory about time. But the question of time is skipped. Is time real? In what sense is the present real or physical? Does this present have duration? Is it discrete or continuous? Is time a mind independent reality or is it

simply the term and measure we use to talk about what is mind independent (i.e. what is real)? Tallant even acknowledges that presentism literature largely omits thorough discussions of “is present”, but does nothing to rectify this omission. To say that only present things exist is to skip past asking the question of existence about time. Again elsewhere, he notes of Williamson,

What is missing, Williamson thinks, is an account of what ‘is present’ is supposed to mean. That is, in the context of the metaphysics of time, what does ‘is present’ add to our theorizing such that one can assess claims such as ‘nothing is non-present’ or ‘all things are present’? (Tallant 2017, 17)

and Tallant responds by conceding that

If the terminology is as obscure as Williamson suggests, then so be it. Nonetheless, there seems to be nothing so obscure about the existing presentist case. (At least, no such concerns have been raised in the literature) (Tallant 2017, 17).

Tallant’s dismissal of this ambiguity and of Williamson’s and Deasy’s critiques as unimportant, as well as Tallant’s own failure to address those concerns, stems from, I argue in section two, an unacknowledged *use* of time. He, like many presentists, is using time to help him define what things exist, rather than offering a definition of time. And there is nothing wrong with using time in this way if we recognize the use and have an account to defend it.

V.2. A Response to Tallant: What Happened to Time?

While we might offer a variety of interpretations for understanding the debate between Tallant and Deasy, and, more importantly, the inattention that Tallant, and many other presentists, show to defining the present, I argue that understanding time as a tool provides both a rigorous and charitable interpretation. Tallant advises that we begin with basic questions of existence, which means that for time we ought to start with the

question of whether it exists, rather than assume that it does. However, he does not seem to recognize that he is not asking the existence question *about time*. Rather, he is assuming time and using it as a measure by which to distinguish which things exist, i.e. on the measure “future time,” things do not exist; on the measure “past time,” things do not exist; or on the measure “present time,” things do exist. Likewise, “is present”, “is past”, “is future”, are not telling us about time, rather they are marking out the two categories that presentists care most about: “exists” and “does not exist”.

Even if it is the case that time exists and even if its existence were obvious, we still need a proper account of time. In his response, Tallant does not recognize that he is still not examining *time* or providing a rigorous philosophy *of time* (though his account may have implications for a philosophy of time, had he actually chosen to focus on them). While Tallant acknowledges that terms like ‘is present’ are under-defined by most presentists, he does not add clarity to the ambiguity (Tallant 2017, 25). To say that what is present is just what exists and that to be present just means to exist does not actually speak to the nature of time, but rather to the nature of existence. Tallant’s measures (i.e. future, present, and past) are not well defined. We are still left wondering what counts as “now” and how do we measure this present moment? If I want to understand or measure “the now”, knowing what exists in the now is not helpful because it is the now, not the things in it that I want to focus on and examine. I cannot measure the now by reference to what things exist, because the measure for existence is determined by whether they are present. Since whether things exist depends on whether they are present, we need a way of defining the present that does not merely point back to existence.

One notable exception, as Tallant also mentions, is Thomas Crisp (2003). Crisp provides a definition of ‘is present’ or ‘the now’ as a maximally slim object, though this definition is not particularly satisfying because it under appreciates the mathematical difficulties involved in defining an instant. Because the issues in Crisp’s definition take us far a field in mathematical theory, I bracket a careful discussion of Crisp’s definition and the difficulties in attempting to define ‘the now’.⁵⁹

A charitable explanation of Tallant’s oversight, and the one that I advocate, is that presentists do not need a more careful definition of time. Indeed, I think they do not have it just because they have not needed it; but they have not need it because they are using time, not examining it. This helpful response requires that presentists recognize that their theory is not about time, at least not until additional work is done. Here is what is helpful: the imprecise measure of past, present, and future may be precise enough for the presentist’s purposes. “Is present” does not need further defining if it is precise enough for the purposes for which it was developed. After all, there is nothing objectionable about an imprecise measure, if it “gets the job done”.

What counts as “getting the job done” is going to depend in large part on defining what job we need done, or as some have suggested, what why question we are asking and what counts as an explanation (van Fraassen 1988). Take an example of measurement in

⁵⁹Crisp loosely defines the present as a sort of instant (a maximally slim object) where we say that “an object x is slim iff, for any y and z , if y and z are parts of x , then there is either no temporal distance or a temporal distance of *zero* between y and z ” (Crisp 2003, 212). However, it ends up requiring a good deal of careful work in defining and developing measures for an instant before such definitions of the present become useful in the ways that Crisp intends. Nor is Crisp’s definition alone in causing trouble for presentists. The prevalent practice amongst presentists of referencing the present as a universal instant while engaging in debates about relativity theory adds to the confusion. In mathematics and physics, an instant is more clearly defined, however, it is not always clear that presentists are using such definitions. This problem of the present’s duration, that comes from attempting to define ‘the now’ as a universal instant, embroils presentists further in measurement issues rather than extricating presentists from measurement issues, though I save that argument for another paper.

length. If we aim to measure the length of a coastline it is not sufficient to simply assert that we “want to know the length of a coastline”. We must explain what counts as a coastline and in what scope we are interested? Are we interested in the distance a sailboat would sail along it, the distance a rowboat would travel along it, or the distance a person would walk along it? Each distance will be different because the sailboat, rowboat, and person will all have different tracks and so longer and shorter distances to cover. For example, the distance a person would walk to traverse the coastline will not be a helpful distance to give a sailor who is trying to calculate the distance she must sail her boat. Any one of these distances, not to mention any other distances of the coastline, might be taken as precise or imprecise depending on the definition of a coastline, the parameters, scale, etc, that we have initially adopted (Costanza 1989; see also van Fraassen 2010, 165-179). What counts as a good, precise measure of the distance of a coastline will depend on what we want measured and the context in which we ask our questions (van Fraassen 1988, 143-150; Tal 2011; Boesch 2017). Likewise, what counts as a good definition of the present will depend on what use we plan to make of the measure: ‘present’.⁶⁰

Here is how my response on behalf of presentists continues: perhaps presentists have not devoted more effort to defining the present or any other aspect of time just because they only need a fairly crude measure for their purposes. They are not trying to figure out the duration of the present or ask whether ‘the now’ is discrete or continuous

⁶⁰The physicist, psychologist, and metaphysician will all have quite different expectations of what counts as a good measure of the present (See Tal 2016; Audoin and Guinot 2001; Vroon 1974; Baron and Miller 2016, 29-52; Varela 1999; and Zimmerman 1996). It is likely that they will not find each others’ measures useful because they are each aimed at quite different goals—the physicist, in some cases, is measuring changes in the states of atoms, the psychologist may be interested in measuring experience and consciousness, while metaphysicians, such as presentists, are interested in asking fundamental questions about existence.

just because they do not need such precise measurements to talk about what exists and what does not exist. “Past”, “Present”, and “Future” are crude measures that get the job done by providing the necessary categories: the measure, “things that exist,” and the measure, “things that do not exist”. It doesn’t tell us much about time because ‘is present’ isn’t needed to help clarify time, but to clarify whether a thing exists. Sometimes things exist and when they do, we call that the present; sometimes they don’t exist and they can fail to exist in a couple different ways: one because they have not begun to exist, we call that future, and one because they stopped existing, we call that past (Tallant 2017, 25). Such loose measures get the job done for the presentist, but would likely be entirely unsatisfactory for many others. Tallant does not need to further define time or the present unless he aims to provide a rigorous account of time.⁶¹ If he is interested in a theory that addresses metaphysical questions of existence, for example, then a fairly crude measure will do just fine.

If time is used in service of questions about existence we will probably need to say a bit more concerning the subject of such questions. One thing we might think that questions of existence, particularly of the sort that presentists ask, are concerned with is substantial change. Coming into being and passing out of being (or existence) is one type of change: substantial change. Substantial change implies a temporal notion of ‘coming to be in time’, likewise for passing away. For presentists, the temporality of this change just means that we can measure the coming to be. Moreover, to say that the temporality of change can be measured means, somewhat literally, that we are able to correlate its ‘size’ with the ‘size’ of some other change that we have measured, such as a ticking

⁶¹Further questions of measurement with respect to things like duration and discrete versus continuous time become important for presentism to address, though such questions are largely neglected in conversations about time. I bracket such considerations and arguments for this paper.

clock. We do a similar thing when we compare lengths by correlating the length of one object with another, such as a ruler.

If this explanation is accepted, it may also explain why presentists appear largely unconcerned about the details of the nature of time. Presentists don't need a precise measure of substantial change to mark the difference between 'the time that a thing didn't exist' and 'the time that it does exist'; just as we don't need an atomic clock to distinguish day from night, the sun will do quite nicely most of the time, in many parts of the world. Asking what duration the present has or whether time is continuous or discrete will seem excessive and even misguided to presentists just because they have not been about the business of carefully defining the present with respect to what time is; they do not need a precise definition anymore than a farmer needs an atomic clock to determine when to plant, the projects of each require far less precision of their measures. The phrase 'is present' is so often neglected and insufficiently defined (as Williamson complained) because presentists see it as having a straightforward meaning. And 'is present' *has* a straightforward meaning to presentists just because it is acting as a tool (a tool that does not need to be particularly precise) in their attempts to define what does matter (to them). The phrase 'is present' is not sufficiently defined for an account of time because they are not trying to give an account of time. Presentists simply want to assert that some things exist and some things do not and fairly crude measures (ticking clocks, or even orbiting moons) will do for that purpose (e.g. "When the moon was full, the thing did not exist, and when the moon was crescent it did"). Time has become a means, a measure by which to orient and compare one change to other changes.

As mentioned, I willingly leave open the possibility that presentists can turn presentism into a theory of time but I also want to provide an option for presentists to avoid doing that work and that option comes at little cost to them or their interests. If presentists are not interested in making their theory about time, then they will need a theory of time. In the next section, I provide a sketch of a theory of time where time is nothing more than a measure of change. Presentists might find adopting this theory attractive because, among other things, it carries with it relatively few metaphysical commitments about questions of existence while also allowing room for them to preserve aspects of their theory that they care most about. Finally, the theory of time that I sketch has the added appeal of being able to explain why it is that accounts such as presentism struggle to remain accounts *about time*.

V.3. A Sketch of Time

The theory that time is nothing more than a measure of change, while not new (versions of it dating at least to Aristotle⁶²), is not currently discussed much in light of epistemology of measurement literature—literature that makes it a much stronger and more appealing theory. As theorists flesh out what it means for a thing to be a measure and the processes involved in measurement, the idea that time is a measure of change

⁶² It is worth noting that Aristotle gives an account of time as a measure of change (Aristotle, *Physics*, Bk. IV. Parts 10-13). Aristotelian scholars debate whether Aristotle meant that time cannot be separated from change or is, more radically, nothing more than a measure of change. Some Aristotelian scholars argue that Aristotle did not mean to claim that time is nothing more than a measure of change so much as to claim that time is, and also is a measure of change (Coope 2001). It is not clear what is at stake, besides some people's intuitions about time, if we take Aristotle to mean that time is nothing more than a measure of change. In any case, it does not matter to this sketch what Aristotle meant and so I bracket his account to avoid embroiling this project in interpretative differences over exactly what Aristotle intended in his account of time.

becomes not only a useful idea, but even has the potential to be a quite robust theory of time.

Much is often made of human intuitions about what is. Whether we should place so high a value on our intuitions about the way the world is, is a question for another paper. Still, for those who care that our account of time be intuitive, there is intuitive appeal in this account. We do not experience time; we experience change. The whole course of our lives is an experience of change: sun sets and rises, breathing in and out, waking and sleeping, births and deaths, thoughts passing through our minds, and so on, all cycles of change. And we want to talk about and compare these changes; we want to examine and learn about the changes we experience individually and as a species, not to mention as a whole universe. Our experience suggests that if there is anything we encounter in the world around us, it is change—we speculate about whatever else might be true of the world around us based on the changes we encounter. So we develop language, theories, and measures by which to examine, compare, and reference these changes; changes that make up our entire existence. What tools do we use to measure change? One tool is time. If we think that time is a measure of change, then we will want to say more about time as a measure of change and the benefits of this theory of time.

V.3.i. Time as a measure of Change

If time is not something to be measured but rather a means by which to measure change then what exactly is it that time is measuring? I have argued that it may be used to measure various aspects of change, depending on the field of study and object of study, and so in one sense we might say that time is not limited to measuring any one aspect of

change. On the other hand, I have suggested that time is a measure like distance, but then what is it that time measures? Filling out these ideas yields more flexibility in how we understand this notion of time as well as a more specific picture of it.

An important benefit in understanding time as a tool is that it is flexible enough for us to put it to a variety of uses. If we think that there are different types of change, physical and metaphysical, then we ought to study these aspects in their own rights and I have already suggested that this is precisely what we find physicists and metaphysicians doing with respect to physical change and substantial change. I have also suggested that there are other types of change for example psychological changes, and that measuring them may amount to measuring changes in psychological states or our experience of change. So in some sense the subject or content of what we measure is loosely defined, thereby allowing freedom in how we use time and what we measure with it.

And here is the ‘some sense’ I have in mind. In the same way that distance is a tool for comparing endpoints (or boundaries of objects), time is a tool for comparing starts and stops of change. Like time, we may say that distance is not an absolute property but rather a comparative one so that when we talk about measuring distance we do not mean that we are getting at an absolute property but rather comparing some distance against another. Both distance and time measure comparative properties. Time is a comparative property aimed at measuring the beginnings and endings of changes for the purposes of comparing one change to another, just as distance is a measure of boundaries or starting and stopping of objects for the purpose of comparing one distance to another. We use yard sticks to compare one distance to another, not because the resulting measure reveals an absolute property called distance, but because we can now

say something about how the distances relate to one another e.g. this one is shorter than that one and the gift will fit in the box. Likewise, we could talk about a clock as ‘measuring time’, but we would not want to mistake time as an absolute property that we have measured. Rather, we are using our clocks to compare times to each other so that we can talk about whether the swim meet will take up the whole morning or whether stopping to get a cup of coffee will make me late to my next appointment.

While understanding time as allowing us to make certain kinds of comparisons affords a good deal of freedom in what we choose to compare, this view of time does not leave time so loosely defined that we cannot say something a bit more specific about what it measures. Time measures the beginnings and endings of things *for the sake of comparison*. Rather than imagine that we are measuring the amount of time that passes between the beginning and the end, I argue that there is no ‘thing’ that time measures to which we should be metaphysically committed. Our measure puts a number to the change (bounded by a beginning and an ending) for the sake of comparison with other beginning-ending pairs. We *define time* to be ‘so many ticks of this clock between the beginning and the ending’ because this definition *works* for the purposes that we have in mind (such as predicting whether I’ll be late for the appointment, whether the meet will take all morning, etc.).⁶³ Thus while we are more free to use time in a variety of conversations, our freedom requires that we conceive of time as constructed for a specific purpose. We are not measuring some absolute property or thing but, more pragmatically, constructing a measure (e.g. so many ticks of a clock) by which to make useful comparisons (such as between events).

⁶³Thank you to Michael Dickson for the articulation of this paragraph.

We might likewise generalize the idea that we measure the beginning and endings of changes for the purposes of comparison from physical examples to metaphysical examples. In some metaphysical conversations, we consider beginnings and endings of a thing's existence in order to compare the existence of one to another. For example, debates between A and B theories can be understood as attempts to measure and compare the existence of one thing to another on the measuring 'clock' of past, present, and future.

Importantly, at least for our physical theories, the idea of both time and distance as being comparison properties leaves open questions about how perspectives and particular reference frames change the measurement outcomes. Moreover, because time is merely allowing us to make certain kinds of comparisons, what we want to compare plays an important informing role in what our measurement looks like so that we can anticipate quite different sorts of conversations and measurement outcomes, depending on what we have chosen to compare.

What I have not attempted to do in this project is clarify areas in epistemology of measurement that are currently debated, such as what counts as a model. Much of the current work in epistemology of measurement aims to reduce the ambiguity involved in our measurement practices (Knuutila 2005). For example, what counts as a model versus a tool versus an instrument? Sometimes the answer is straightforward and sometimes the differences between them grow obscure (Knuutila 2005; and van Fraassen 2012). This area of epistemology of measurement will need as much work with respect to time as any other sort of measurement. Still, we have some start: that is, we know that what we aim to measure is the beginnings and endings of things (physical, metaphysical, psychological or otherwise) for the purpose of comparison. We have many examples of instruments

such as atomic clocks, analog clocks, sundials, and water clocks. And our awareness of time as a measure will provide space and motivation for doing the further work required to clarify our uses.

V.3.ii Benefits of this Theory

Viewing time as a measure carries with it the added benefits of being able to explain the current conversations occurring about time while also allowing us to predict some of the difficulties that other accounts encounter as they attempt to explain time. Meanwhile, there remains ample space for a wide range of metaphysical positions.

For those who worry that this account requires radical anti-realism, it is important to note that this account leaves room for realists, just not with respect to time (unless one finds it satisfying to acknowledge that we have real instruments of measurement, constructed though they may be, such as yardsticks and clocks). It is true that the theory I have sketched here does not leave room for one to be a realist about time. However, there is ample room for being a realist about other things, such as change. And if it turns out the case that most theories, in attempting to talk about time, end up talking about some aspect or other of change, then it might also be the case that realists never were realist about time so much as about change; and so the motivation to be realists about time might fade.⁶⁴

That presentists, or anyone else, use time to help them compare a thing's existence against other things' existences is not new or surprising. What is surprising is

⁶⁴Moreover, since I am not arguing that it is obviously the case that time is nothing more than a measure, I bracket the realist objection that it might still be the case that time exists and we merely have no good way of observing and measuring it. It may well be the case, as the realist says, and yet at some point we may wonder what reason we have to insist on time as a mind independent reality.

that we commonly mistake this project for a theory of time. In actuality we have jumped straight past developing a theory of time, to an application of time—taking time as a measure of change explains why we make this leap: time is a tool and we use it accordingly, albeit often unconsciously, to discuss, evaluate, and measure the thing we are most concerned with, change. We are simply mis-categorizing these conversations as being about time. To have a proper conversation about time requires that we remain more aware of the difference between using time as a means of measurement in a given conversation and actually discussing time itself.

Viewing time as a means of measurement also justifies the manipulation and re-defining that we do in order to make time fit the needs and constraints of particular conversations. For example, does an instant have duration? The presentist who adopts the view that time is a measure of change is free to craft an answer suited to her purposes with less worry that there is some sleight of hand involved. The point is that there is no ‘natural kind’ of thing called ‘an instant’, whose length might be a matter of discovery. Rather, we can specify, for whatever purposes we might have, what ‘counts’, for us (e.g. for our purposes of describing change), and what is meant by ‘an instant’ or ‘the present’.

Likewise, for additional questions not addressed in this project, such as questions about whether time is continuous or discrete, we may find that having a more flexible account of what time is allows us to shape our definition of it to suit the purposes for which, and the contexts in which, we use time. For example, where it seems that time is continuous, it seems so just because either our theory presupposes a continuum, as in continuous mathematics, or the changes we are considering appear continuous. In either case, the parameters of the particular conversation, more than the “reality of time” will

determine whether we represent time as discrete or continuous. Time is a tool that allows us the luxury of adapting it to our individual conversations and contexts.

Given all that we keep on this theory of time, it is not clear that we lose anything of real importance. Even our intuitions about the passing of time are not lost, after all the “flow of change” is all that we ever observed when we talked about the “flow of time”. All our temporal language remains because it still does the important work it has always done—we could not get on without temporal language because it is one of our ways of navigating the ever-changing world. We do not lose our language or our intuitions; we just understand them better. What is altered is how we frame and understand our metaphysical conversations and the problems we see as needing addressing.

One of the benefits that comes with accepting time as a measure of change is that we already have developed justifications for the ubiquitous practice of manipulating our measurement tools, instruments, and models (van Fraassen 2011, 179-185; Poincaré 1905). If time is a tool then we can reconcile and defend our willingness to adopt different uses of time in different contexts without need for a unified use of time. We can recognize the disparity in topic, focus, and language of our various conversations “about time” and be clearer about the work that needs doing and what the real difficulties are in a given theory. For example, if, for presentists, the real difficulties do not have to do with time but with questions of existence then presentists may find that their debates about the compatibility of presentism with relativity theory also need recasting.

V.4. Conclusion: Implications for Theories of Time

Quite apart from whether one accepts my account of time, presentists still face the challenge of showing that presentism is a theory about time. Tallant’s attempt to show

that presentism is properly a philosophy *of time*, gave us some inkling of how difficult it will be for presentists to address questions about time sufficiently enough for us to accept their account as *about time*. Either they will need to do more work to define the present or they will need an account of time.

While re-casting presentism as a theory about substantive change does not require that we therefore endorse the account of time I offer, it does offer a certain kind of support for endorsing this account. It goes something like this: the theory that time is a measure of change says that we should expect that attempts to talk about time will end up focused on some aspect of change. We observe that presentists, while attempting to talk about time, do in fact seem to be focused on a metaphysical aspect of change (just as our theory predicted they would). That our theory better explains our observation than do other accounts gives some credence to our starting supposition that time is a measure of change. The idea that time is nothing more than a measure of change is not a new theory and it happens to be particularly helpful in explaining and framing current conversations about time.

If we understand time as nothing more than a measure of change, we can predict that metaphysical theories that are traditionally categorized as *about time* will in fact be *about some aspect of change*, such as existence. While we may find that some theories are properly about time, we may also find that many theories, formally considered theories of time, are better categorized as theories about change. For example, while the substantive aspects of the Presentist, Growing-block, Moving Spotlight, and B-theory debates will continue beyond this project of re-categorizing, it seems plausible that we will find that they are not, properly speaking, theories about time—they are theories that

employ time as a tool for evaluating questions about substantive change. Moreover, we can understand how our discussions of change as existence might relate to or use a theory of time.

If we do not adopt the theory of time that I have sketched, we will need to develop some other theory of time that does not merely collapse into a theory about something else—such as change. If the theory of time that I have sketched here is correct, we may actually find it quite difficult to develop a substantive account of time that does not reduce time to the study of some aspect of change. It is telling, perhaps, that we can find ways to describe change without reference to time, e.g. Aristotle's account of change, but struggle to describe time without reference to change.

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