A Perspectival Account of the Flow of Time

Jules Rankin

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School of History and Philosophy of Science

Faculty of Science

The University of Sydney

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Statement of Originality

To the best of my knowledge, the content of this thesis is entirely my own work. This thesis has not been submitted for any other degree or purpose. I certify that the intellectual content of this thesis is the product of my own work, and that all sources and assistance received in preparing it have been acknowledged.

Signature: Name: Jules Rankin

Abstract

This aim of this thesis is to provide an account of our experience of the flow of time. I will be employing a naturalistic approach to this philosophical question, which chiefly involves being heavily influenced by the natural sciences. I explore ways of incorporating the flow of time in our fundamental physical theories and end up defending a view that is consistent with there being no flow of time present in our fundamental physical theories. Instead, the flow of time arises from the adoption of a particular *perspective* that an embedded agent with a particular cognitive architecture possesses. I go on to describe such an agent in detail and show how this account sheds light on a variety of philosophical and scientific issues.

I argue that this account of temporal flow naturally lends itself to a variety of scientific and philosophical applications. From explaining disparate sets of psychological phenomena under a unified mechanism, to providing insights into how to build better artificial intelligence systems, to addressing long-standing debates within the philosophy of time surrounding the relationship between our experiences of time and the metaphysics of time, and finally pointing to new directions for empirical work into our experience of time.

I believe that the account presented in this thesis does justice to our experience of the flow of time, its ubiquity, and its seeming intangibility. While other accounts have argued that such an experience is a mere illusion or cognitive error, I argue it can (and should) be thought of as veridical and that it arises from the core of what it means to be an embodied agent.

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The author has no relevant disclosures to make in relation to animal or human ethics, intellectual property, or further assistance or editing in the writing of this thesis. All figures that are not my own have the relevant appropriate citation.

Three of the principal chapters of this thesis are adapted from articles written for independent publication, which were written during the period of my candidature. The first of which is published and was co-written with my supervisor, with only the sections that I made the primary intellectual contribution included in the thesis. I have made small changes to the text in order to improve the cohesion of the thesis, including for example the addition of cross-references between chapters. The published article is the following:

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As supervisor for the candidature upon which this thesis is based, I can confirm that the authorship attribution statements above are correct.

Name: Dean Rickles, Signature: Date: September 29, 2025

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Chapter 1

Introduction

This thesis is about trying to understand what we mean when we say that "time *flows*". On the one hand, this statement seems utterly ordinary and uncontroversial. However, under further scrutiny, this statement can be viewed as very strange indeed. The ultimate goal of this thesis will be to make it 'un-strange.'

This project will largely be constructive, building up how to resolve the apparent tension between two important ways of understanding time. These ways are analogous to Arthur Eddington's famous 'two tables', where on the one hand there is the familiar table on which I am writing these words, while on the other hand there is the table described by our best scientific theories, which suffice it to say is of a very different character.[1] As Eddington put it, "It is true that the whole scientific inquiry starts from the familiar world and in the end it must return to the familiar world; but the part of the journey over which the physicist has charge is in foreign territory" (Eddington, 1928, pg. viii). This thesis will hopefully make a successful return trip.

[1]An example of what Eddington has in mind here is how the first table seems solid while the second table described by physics is mostly empty space.

1.1 Manifest and Scientific Image

One of the tasks of philosophy as a whole is to tell us what the world is like. Sellars (1962) introduced terminology that describes the various ways in which the world presents itself to us. Roughly speaking, on the one hand, there is the knowledge of the world presented to us from our everyday sensory experience, called the *manifest* image. On the other hand, there is the image of the world that is presented to us by our systematic scientific inquiry and theorising, aptly called the *scientific* image. Sellars himself thought of there being three distinct approaches to how we should think about the relation between the manifest and scientific objects (in Sellars' words "imperceptible particles," standing in for a paradigmatic scientific object):

> (1) Manifest objects are identical with systems of imperceptible particles in that simple sense in which a forest is identical with a number of trees. (2) Manifest objects are what really exist; systems of imperceptible particles being 'abstract' or 'symbolic' ways of representing them. (3) Manifest objects are 'appearances' to human minds of a reality which is constituted by systems of imperceptible particles. (Sellars, 1962, p.26)

One way of understanding the options Sellars sketches out here are answers to the question of which image is primary and which is derived or secondary. (1) says that they are both equally primary, (2) says that the manifest image is primary and the scientific image is secondary, while (3) says that the scientific image is primary and the manifest image is secondary. That being said, we need to be careful as to the kinds of primary-secondary relations one can feasibly make between these two images. Short of solving the mind-body problem, the kinds of relations we can draw across these two images are *functional* in nature. As Sellars puts it, "if thoughts are items which are conceived in terms of the roles they play, then there is no barrier *in principle* to the identification of conceptual thinking with neurophysiological process. There would be no 'qualitative' remainder to be accounted for. The identification, curiously enough, would be even more straightforward than the identification of the physical things in the manifest image with complex systems of physical particles. And in this key, if not decisive, respect, the respect in which both images are concerned with conceptual thinking (which is the distinctive trait of man), *the manifest and scientific images could merge without clash in the synoptic view*." (Sellars, 1962, p. 34, emphasis in original).

Many scientists and philosophers within the contemporary tradition of 'naturalistic philosophy' often prefer (3) given the success of the scientific project. However, this approach can lead us astray and provide us with an overly dismissive attitude towards features of our manifest image. Instead, I take a view that has recently been developed within the field of philosophy of science, which is referred to as *Perspectival* philosophy of science[2]. This approach independently arose from many areas of philosophy of science (ranging from feminist, sociological, and analytic philosophy of science), with the central theme of emphasizing how a given perspective (broadly construed) influences and/or constrains our scientific inquiry. This literature will be very useful in the latter half of the thesis to frame the discussion around how certain proposals of accounting for our temporal phenomenology within our scientific image can be made sense of in the light of the apparent conflict with our manifest image.

This thesis will focus on attempting to resolve the dialectical tension between a certain feature of our manifest and scientific images of time. The following section will describe the ways in which time is represented in each image and will motivate the central puzzle that this thesis attempts to address.

1.2 Is Time like Space?

There is a very robust analogy between the features of time and space. In fact, the standard way of representing time is by using a spatial or geometric analogy of a *time-line*. This is a result of the fact that many of the features of time (and by extension our experience of time) can be successfully modeled by geometric features.

[2]See Massimi (2022) for an in-depth review.

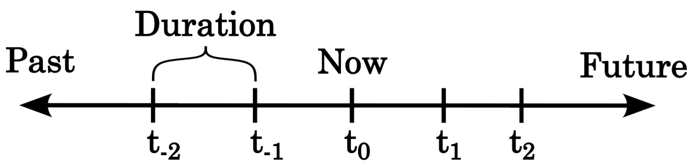

Figure 1.1: Temporal features that can be mapped onto a geometric representation

Temporal Feature	Spatial feature
Present	Indexical origin
Temporal Asymmetry	Metric ordering
Duration	Length

Table 1.1: Correspondence between temporal and spatial features.

A few key examples that are shown in Figure 1.1 and Table 1.1 include our experience of a present moment, which can be modeled as a point along our line that indexes an origin, temporal asymmetry (what is often referred to as the arrow of time) can be represented as a metric ordering on this line that allows us to distinguish direction, and finally temporal duration can be thought of as length measures on this line.

This analogy is so successful that in contemporary theories of physics (in particular the special and general theory of relativity) space and time are in fact unified as two components of a single entity, *spacetime* and hence we have good reason to think that this analogy has deeper implications.

The following is one way of understanding the central puzzle that this thesis attempts to address. Many of our temporal experiences can be mapped onto such a geometric structure *except*, it seems, one important kind of *dynamic* temporal experience. I will call this experience Temporal Flow (TF henceforth). Given this geometric understanding of time, our experience of TF seems utterly mysterious. To highlight this, it would seem strange to say that space 'flows'. We might highlight the fact that space has a continuous geometry, but so does time under this view so this cannot be what we mean when we say that time 'flows' while space does not. In short, it seems like on the face of it that there is nothing in Figure 1.1 that we can point to that would do the job of accounting for our experience of TF. So whatever is going on, our experience of TF seems like a piece of evidence that throws a wrench in our straightforward geometrical analogy of the nature of time. Let us now review the various ways contemporary philosophy of time approaches such issues.

1.3 A first look at Temporal Flow

Before directly tackling TF it is worth first setting up that the philosophy of time are largely structured around two types of temporal metaphysics, those with an A series and B series. This terminology comes from McTaggart (1908) where he describes them as follows; “I shall speak of the series of positions running from the far past through the near past to the present, and then from the present to the, near future and the far future, as the A series. The series of positions which runs from earlier to later I shall call the B series”. The key distinction being teased out here is the difference between a *tensed* and *tense-less* description of time. In the A series tensed facts are fundamental, so statements such as ”it will rain tomorrow” or “Caesar crossed the Rubicon 2073 years ago”. These statements make reference to past, present or future. This is in contrast to the B series in which tense-less facts are fundamental such as “the rain occurred the day after the wedding” or “Caesar crossing the Rubicon occurred in 49 BC”. Notice how in tense-less statements, temporal events are always described *relative* to other events (in the rain case relative to the wedding day and in the case of Caesar, relative to the start of the Gregorian calendar).

McTaggart also notably introduces a third C series in which events have an ordering but not *direction*. A more formal way of putting it is that events only have an ‘in between-ness relation’. So the C series does not distinguish the orderings A B C and C B A since in both cases B is in between A and C. While much of the debates in the philosophy of time surround the A and B series, in the context of modern physics the C series is relevant for describing time symmetric laws which do not provide an intrinsically preferred direction since for any solution to the laws there will always be a corresponding time-reversed solution. This will be explored more in Chapter

2.[3]

It is against this metaphysical backdrop that we can do a first-pass exposition of what is meant by TF. Price (2011) gives three conditions for genuine TF. They are: a privileged present, temporal direction, and a "flux-like character". As mentioned in the previous section, the first two of these features have garnered much attention within the philosophy of time and philosophy of physics[4]. However, it is this last criterion, the dynamic or "flux like character" of TF that this thesis intends to focus on, in part because it is the one that has proven the most slippery for both philosophers and physicists to get a grip on. Price, for example, discusses how this "flux-like" character of TF more or less amounts to saying that time passes at a certain *rate* (ie, one second per second[5]). However, as a starting point we will take a different approach and try to understand TF on its own terms, so to speak.[6] Namely, that there is something about our temporal experience over and above the B-theoretic earlier / later relations between events. As Dainton (2013) puts it, experiences of TF are "distinctively dynamic sensible appearances, sui generis forms of experience which are not reducible to (or composed of) sequences of static appearances." Furthermore, that these experience are caused by some property or feature that we can ascribe to objects and/or sets of events which is currently missing from the standard scientific image, but is nevertheless necessary to provide a comprehensive account.

Despite remaining committed to a B-theoretic temporal metaphysics throughout this thesis, I will now present various A-theoretic type metaphysics and their respective treatments of TF. The motivation for these introductions comes from the fact that at least part of the motivation for adopting various A-theoretic metaphysical views is their apparent alignment with our phenomenology. The hope of this thesis will

[3]For a more in depth discussion of McTaggart and how his work has framed much of the contemporary work in the philosophy of time see Dyke (2002).

[4]See Albert (2000), Callender (2008, 2017), Farr (2020a), and A. Fernandes (2022) for examples of standard treatments regarding the status of a privileged present and temporal direction from an Eternalist/B-theoretic perspective.

[5]Miller and Norton (2020) asses whether time can flow at different rates.

[6]We will nevertheless return to the discussion of rates of flow in Chapter 5 & 6.

be to show that at the very least our phenomenology of TF (properly construed) is at least just as perfectly compatible with a B-theoretic metaphysics as it is with the A-theory.

1.3.1 A-theoretic passage

An important feature of the A-theory is that it attempts to capture the intuitive notion of what has come to be known in the literature as *temporal passage*.

> Temporal Passage (TP) = $^{\text{df}}$ There is a fact about which instant of time is objectively present. Moreover, which instant of time is objectively present *changes*.

This concept initially seems unproblematic until we think a little on what it would mean to say 'which instant of time is objectively present changes' since for the present to change it would seem necessary for it to change *with respect to something*. Much of the work that A-theorist do in accounting for TP is providing way of understanding such change of the present.[7] Moreover what I have been referring to as temporal flow, under an A-theory is the *experience of* TP. Loosely speaking, the A-theorist argues that given that we have an experience of TF, the best explanation for such an experience is the existence of temporal passage as an objective feature of the world. I take it that one of the key motivations for adopting an A-theory of time is this move, often refereed to as the Argument from Experience.[8]

Notice I said *an* A-theory (not *the* A-theory), since as we will see the A theory is not one kind of temporal metaphysics, but rather a family of metaphysical views. Each has a subtly distinct treatment of TP and how it links to our experience of TF. I will be briefly examining the main kinds of A theoretic metaphysics in the subsequent section, focusing mainly on how each understands TP.

One approach that is shared by various A-theorists by introducing the notion of

[7] See Williams (1951) for an influential argument against such accounts of passage.

[8] See Dainton (2023b), Le Poidevin (2007), Paul (2010), Frischhut (2015), Baron (2017b), Kristie (2017) for a discussion of various responses to the Argument from Experience.

hypertime[9]. This, I hope to show in Chapter 5 that much like times direction, or a privileged present, there is a sense in which the notion of hypertime that is used to understand TP and TF can be thought of as a product of our an epistemic or perspectival circumstances rather than a direct product of our ontology.

A distinction that arises in the philosophy of time literature is the distinction between so-called 'anemic' and 'robust' passage. This distinction was introduced by Skow (2015) to help distinguish the use of the term TP as defined above and those who use it to merely describe so-called 'at-at' change. Where 'at-at' change boils down to saying something like "P at time t_1 and Q at time t_2"[10] which is consistent with a B-theoretic metaphysics. Skow's main objection then is that any notion of TP that is worthy of the name ought not be compatible with the B-theory.[11] This is partly the reason why I use the terminology of Temporal *Flow* to refer to the target phenomenon that I will be attempting to recover in this thesis, to distinguish it from the already theoretically-loaded terminology of temporal passage. Nevertheless, I will keep referring to passage at times since it is a useful conceptual foil to contrast my view with.

1.3.2 Presentism

One of the most radical form of A theoretic temporal metaphysics (at least compared to how I have set things up in this chapter) is presentism, which, stated loosely, claims that only the present moment exists. This account has a purported initial intuitive appeal given that there is a sense in which one only have direct epistemic access to objects in the present, so if one thinks there is a close link between epistemology to ontology then presentism seems to have purchase.[12] I nevertheless call this view radical since while it emphasises the primacy of the immediate present,

[9] Sometimes also refereed to as meta-time or supertime.
[10] Where P and Q might be refer to the hands of a watch at different positions.
[11] See Maudlin (2018) for critical response to Skow regarding the distinction of robust vs anemic passage. Also see Deng (2019) for an example of an articulation of one such 'anemic' account of passage.
[12] For various accounts of presentism see D. Zimmerman (2008) and D. W. Zimmerman (1996), Tallant (2010), Deasy (2017) & Dawson (2021).

one has to give up on the existence of *all* other moments in time.

Notions of passage or temporal flow within presentist accounts vary, but one common strategy is to have an irreducible notion of change as (say) a property much like position. This allows the presentist not to rely on referring to other times to define change, since they don't exist.[13]

A novel presentation of presentism that attempts to temper my claim of presentisms radical nature hinges on the notion of *grounding* is given by Baron (2015). Put simply, it upholds the central tenet of presentism, that only presently existing things exist *simpliciter*, but maintains that past and future things also exist in some sense, but only in virtue of present things. This account attempts to both vindicate our intuition regarding the present but without having to bite the bullet regarding claims regarding the nonexistence of facts about the past (and potentially future).

A detailed critique of presentism is that by Tallant and Ingram (2021) in which they argue that one of the challenges with presentist accounts is that there is no 'theoretical core'. In their article, Tallant and Ingram outline various metaphysical proposals that have been labeled as 'presentist' in the literature; however, they show that despite all sharing the moniker of 'presentist,' it is difficult to find a formal feature that they all share that would warrant that name.

1.3.3 The Growing Block

The next kind of temporal metaphysics, called The Growing Block, draws on our intuition that the past is fixed, and the future is open. Given this, the Growing block view loosely states that both past and present moments exist, while future moments do not.[14] However, as the name suggests, the boundary of what is present *grows* such that events that were present become added to the fixed past as the

[13] Contra the standard Argument from Experience introduced in the previous section, Dorato (2015) provides an explicit argument against presentists ability to account for our experience of time.

[14] For various characterization of the Growing Block metaphysics see Broad (1923), Tooley (1997), Earman (2008b), G. Ellis (2014), G. F. Ellis and Goswami (2014) & Deng (2017)

boundary of the present evolves.

A notable critique of the growing block view by Braddon-Mitchell (2004) points out that under the growing block view there are now two distinct notions of 'now'. The first is the indexical present of moments in the objective past along with the objective present at the edge of the block. In short, Braddon-Mitchell points out that there is a radical epistemic indeterminacy of whether now (indexically) is now (objectively) since there are many more moments in the objective past that have the capacity to be now (indexically) but not now (objectively).[15] We will see in the next chapter that views similar to the growing block will be defended by proponents of Causal Set Theory (Dowker, 2014, 2020; Sorkin, 2007).

Another kind of temporal metaphysics that is similar in spirit to the Growing Block view is *Shrinking* Block. As the name suggests, it flips the usual picture so that future events possess some kind of metaphysical existence that past events do not. Norton (2015) describes his version of a Shrinking Block view as a 'burning fuse' model in which the distinctive feature that this model helps illustrate is that future events have the capacity of 'becoming present' that past events do not have. Hence once the present (the burning end of the fuse so-to-speak) arrives, they have said capacity is lost, they have been burnt.

1.3.4 Moving spotlight

Our next A-theoretic metaphysics attempts to have the best of both worlds with regard to A and B theories. The Moving spotlight claims that all moments in time exist, however there is a privileged present (the proverbial spotlight) that sweeps across these moments. [16] Temporal Passage in this view is the movement of the spotlight across the block. A move that is often made to distinguish the moments that are 'lit up' by the spotlight and those that are in the 'dark' past and future is to claim that it the presence of consciousness that distinguishes them. Consciousness

[15] For a response to Braddon-Mitchell's critique see Forrest (2004)

[16] For various accounts of moving spotlight metaphysics see Skow (2011a, 2012), Cameron (2015), Deasy (2015), Spolaore and Torrengo (2019), Miller (2019a).

is therefore the byproduct of this spotlight and so our phenomenology of temporal flow is that associated with the movement of consciousness across the block.

1.3.5 Dynamic Branching

The final A-theoretic temporal metaphysics that we will be looking at are so-called Dynamic Branching theories.[17] Dynamic Branching is partly intended to address modal intuitions of distinct possible futures.[18] This is related to the motivation behind the growing block, however in a more modally constrained way such that compared to the growing block in which future events were radically undetermined, for a branching metaphysics there is simply a choice between which distinct branches you will be on.[19] Passage in this account would correspond to the 'pruning' of branches. More precisely, the point at which the branches split from the 'trunk' is defined to be the present, and passage is the successive deletion of branches when one of the possible outcomes is determined. So before I flip a coin there are two branches in the future corresponding to the two possible outcomes, and as the coin lands one of those branches disappears and the one that corresponds to the outcome of the coin toss becomes part of the 'trunk'.

1.3.6 Eternalist

The final temporal metaphysics I will discuss will the one that will be the central focus for this thesis, that is an Eternalist metaphysics.[20] This is closely associated with the B-theory in that it does not posit an objectively privileged present, a

[17]See Farr (2012) for a discussion of various accounts of dynamic branching theories where some are notably formulated with B-theoretic metaphysics.

[18]See Earman (2008a), Øhrstrøm et al. (2010) & Belnap et al. (2021) for discussions of dynamic branching from the point of view of philosophy and physics.

[19]One might argue that if there are infinitely different branches that this might start to look like the radical indeterminacy of the growing block. However, even with infinite possibilities there might be some future states that are nevertheless ruled out by some fundamental laws. A straightforward example might be that a given law might predict the position of a particle to land anywhere between coordinates 0 and 1, giving us infinite possibilities, but prohibiting it landing at coordinate 2. In the branching account, this would correspond to having infinitely many branches but nevertheless no branches in which the ball at position coordinate 2.

[20]See Miller (2013) for a discussion of how eternalism relates to the some of the aforementioned views.

distinction between past and future or any primitive objective passage. Eternalism on the other hand simply states all events are on the same metaphysical footing. So the B-theory can be thought of as one subset of possible Eternalist theories.[21]

In addition to the B-theory there is also the lesser known C-theory. Both the B and C theory are both eternalist in that they put all events on equal metaphysical footing, the difference concerns the amount of structure that these events primitively have. In short, under the B theory events have an ordering and direction while in the C theory they only have an ordering but no intrinsic direction.[22] Throughout this thesis I will be referring predominantly to the B-theory since this is the more common terminology used in the literature. However, I will disambiguate when the distinction becomes relevant.[23]

While the previous A theoretic account had features that one can straightforwardly point to that track our manifest intuition and experience of time, the eternalist view looks comparatively very lacking in this regard. All that a B-theoretic metaphysics posits are that all events exist and share before-and-after relations. Thus the onus is then on the proponents of eternalism to argue how, given such a sparse metaphysical base, our experiences of time can arise. There are two main kinds of strategies that we will briefly describe here.

Illusionist

The first account is to grant that our experience of TF represents A-theoretic TP, and hence claim that such experiences are systematically illusory since it does not correspond to any objective feature of our world (assuming we live in an eternalist

[21] I use A and B theory primarily since they are the standard terms in the literature, however I will attempt to use the more generic Eternalism when relevant.

[22] Another way to distinguish B and C-theories is that while B events share a before-and-after relation, C events share an in-betweenness relations. So for the sequences ABC and CBA, B shares the same in-betweenness relation with A and C in both cases, whereas has different before-and-after relations in each case.

[23] The main area in which this becomes relevant is discussing the time-symmetric laws of physics, which heavily suggest a C-theoretic metaphysics since the laws provide no intrinsically preferred direction.

world).[24] This experience is supposedly distinct from our experience of change simpliciter but nevertheless is systematically associated with such experiences of change.

It is then on the Illusionist to provide a reasonable story as to *why* we experience such a systematic illusion when we can perfectly imagine not having such extra tacked-on phenomenology.[25] A related issue is the so-called intelligibility problem which asks how is it that we even understand the difference between experiences of such world that contain TP and those that do not given that we supposedly are never even in a position to experience non-illusory TP.[26]

Deflationary/Error Theory/Reductionism

The final account of temporal flow that we will be discussing is the one most directly associated with what will be discussed in this thesis, broadly categorised as reductionist approaches.[27] This family of approaches are related by the idea that whilst we might have the belief that we experience passage, in-fact we are mistakenly attributing this experience to other features of our experience (or combinations of experiences). So instead of having the experience of temporal passage/flow, all we have is the *mistaken belief* that we have such an experience.

Farr (2020b) argues that a reductionist regarding TF takes the following claims to be true

1. Our temporal qualia amount to no more than the sum of change and motion qualia and related kinds of qualia;

2. Each of these are simply what it is like to perceive the relevant physical phe-

[24] For various illusionist accounts, see Le Poidevin (2007), Paul (2010), Dainton (2013) & R. P. Gruber et al. (2018)

[25] A concrete example of this that I will discuss in more detail in Chapter 4 is the condition of Akinetopsia in which subjects report loosing a sense of the flow of time associated with visual stimuli and instead see 'snapshots' of change.

[26] For discussion of the intelligibility problem see Hoerl (2014), Frischhut (2015), Torrengo (2017) and Miller (2023)

[27] For various reductionist approaches see Hoerl (2014), Braddon-Mitchell (2014), Miller et al. (2019), Baron et al. (2015) & Miller (2019b)

nomenon (motion, change, etc.);

3. There is no extra 'passage quale' that accompanies or unifies such qualia; and
4. Such qualia do not amount to a collective representation of temporal passage as something over and above a passage-antirealist (B-theoretic) ontology.

This strategy is common in the more general philosophical project of recovering our other experiences of time from the scientific image.[28] Another such example is that of an apparent shared present that seems inconsistent with special relativity. Nevertheless given the appropriate low velocity regimes that human being find themselves in, along with our limited temporal resolution, an apparent shared present that serves appropriate pragmatic purposes can be recovered.[29]

A recent example of this strategy directed towards our experience of temporal passage is by Torrengo (2017) who argues that we do not have an experience that represents robust passage, instead he proposes that our experience of TF acts as a kind of *modification* of our more conventional experiences of change and motion. Despite, strictly speaking, arguing against the Deflationary/Error Theory views of those articulated above, he characterises TF as a *phenomenological modifier*, which "do[es] not represent the world as being one way or another, [rather] they typically have an influence on our beliefs based on the content of the concurrent experiences."

Bardon (2023) further distinguishes reductionist accounts in terms of different varieties of *projection*. He distinguished two important kinds of projection in the literature, what Bardon calls "Direct" and "Indirect" projection. Where Direct projection arises from "a misunderstanding of some feature of one's own experience as an objective property of the world" and Indirect projection arises from "an attributional misconception based on our way of thinking about change and/or self-representation in relation to change" (Bardon, 2023).

Deng (2013) and Sattig (2019b) both argue that our experience of temporal flow is in

[28]For examples of such broader projects see Price (1996), Prosser (2016), Callender (2017) & Torrengo (2018).

[29]See Callender (2008) & Butterfield (1984) for an analysis of a the common now in relativity.

fact *veridical* within a B-theory. This thesis will end up arguing along similar lines, and flesh out what such an account would look like with considerations ranging from metaphysics to psychology. Putting it simply, referring back to Farr's 4th claim characterising reductionism, instead of TF representing temporal passage, I will end up arguing that our experience of TF represents features of our experience that correspond to a kind of higher-order change. This can be thought of as TF representing (in part) changes relative to an agent's internal model of the world. In other words, it is a combination of *both* of Bradon's Direct and Indirect projection.

1.3.7 Motivations for adopting Eternalism

The specific temporal ontology that I will be adopting throughout this thesis is Eternalist which amounts to saying that the world is 4 dimensional, with all spatio-temporal locations being on equal metaphysical footing. I stress the temporal aspect since this thesis will engage with independent ontological systems that hope to shed light on the temporal aspects of our ontology. That being said, many of the arguments and proposals I will be putting forward are perfectly compatible with various A-theoretic ontologies. The primary reason for adopting a B-theory ontology is that I take A-theorists to be making a kind of category mistake with respect to the nature of spacetime. The paradigmatic A-theorist move is to take something that looks like spacetime (otherwise called a block universe picture) and then add temporal-like features to it (ie, the growing block, moving spotlight, dynamic branching theories, etc). I think this move is a mistake.

I take the phrasing of "block universe" invites us to think of ourselves 'standing above' an analogous 3 dimensional block (given that many of us cannot visualise a 4 dimensional block) holding it out in front of us like we might a loaf of bread. When we do so, it is extremely tempting to imbue this block with all of the standard spatio-temporal features that we would all other physical entities we might imagine (coffee table, tennis racket, laptop, etc). Given that these familiar physical entities can change, rotate, bend, stretch, etc, it seems conceptually irresistible to imagine spacetime doing the same. However I want to argue that we do not have very good positive reasons to make this move. Especially since these everyday intuitions are being applied to a very different kind of object than the usual kinds of physical entities we find around us. Spacetime is the object who's job it is to represent spatio-temporal relations between physical entities. From that description, potential spatio-temporal properties *of spacetime itself* are of a different kind.

Spacetime is the entity who's job it is to represent spatio-temporal relations between events. Concepts like motion and change are to be "read off" the internal structure of spacetime. Spacetime itself does not (or need not) have spatio-temporal features. This view is motivated strongly from how it is treated in the Special and General Theory of Relativity where an eternalist 'block universe' interpretation is usually preferred among philosophers that are heavily influenced by physics. That is not to say that it is a settled matter. There are notable results from Quantum Mechanics such as the Kochen and Specker (1990) theorem which puts pressure on a straightforward block universe view.[30] However, given that the combination of General Relativity and Quantum Mechanics is still an open scientific question, the motivations for eternalism that arise from scientific considerations of them are similarly provisional.

Nevertheless, I take it that since the eternalist view is *currently* well supported then the goal of the account presented in this thesis is to at least show the *possibility* of providing an account of TF within an eternalist metaphysics. Given that much of what is presenting in this thesis is in fact compatible with A-theoretic accounts, my primary goal is not to present arguments *against* A theorist view, rather the goal is to block a common style of argument against the Eternalist that says that their view is incapable of accounting for the dynamic character of our temporal experience:

P1: We ought to adopt a temporal metaphysics that can fully account

[30] This is due to the fact that, Kochen-Specker theorem rules out the possibility that all observables of a quantum system having definite values at all times if one is committed to statistical independence and the correspondence between observables and projection operators on Hilbert space (Held, 2022).

for our temporal experience.

P2: Our experience of Temporal Flow can be accounted for within the A-theory.

P3: Our experience of Temporal Flow is left unaccounted for within the B-theory.

C: Therefore, we ought to adopt the A-theory over the B-theory.

However, given that there are many other reasons one might find the B-theory attractive[31], if the above argument can be deflated, then this would not be an argument *against* the A-theory per-say, but rather an argument against choosing the A-theory over the B-theory on the grounds that it better explains our experience of TF. To do so, this thesis will attempt to show that **P3** is ultimately false and hence show that the conclusion is unjustified.[32]

1.4 Aims of the thesis

The higher-order aim of the thesis is to embody the naturalistic stance and integrated interdisciplinarity of Philosophy of Science. This epistemological stance motivates an approach that not only involves scientifically informed philosophy but also in-part shares the intellectual *goals* of science, to understand the natural world. In other words, this thesis hopes to be an example in which philosophical work that is continuous with scientific work.[33] As evidence for this, I draw heavily on scientific literature, particularly in physics and the cognitive sciences to inform the philosophical positions I lay out.[34] Despite this, there will be points of departure from the

[31]Here I have in mind a variety of philosophical work done on the analysis of truth-conditions, truth-bearers, and change. For influential examples see W. V. O. Quine (2013), J. J. C. Smart (2014) & Sider (2001).

[32]This is independent of the potential reasons for/against provided by the physical sciences.

[33]I follow Dyke (2013) who argues that our temporal metaphysics world should attempt to cohere as closely to the natural sciences as possible. For more on philosophical naturalism more broadly, see Braddon-Mitchell and Nola (2009).

[34]See Braddon-Mitchell and Miller (2017) who argue in favour of philosophers engaging with the special sciences when attempting to understand questions such as the ones that are tackled in this thesis.

scientific goals into what might be called 'pure metaphysics'.[35] Nevertheless for the most part this thesis will attempt to contribute not only to philosophical debates but to a variety of scientific ones, by clarifying conceptual confusion, considering appropriate empirical methodologies and proposing novel directions for research. Given all of these high level motivations, the more direct aims of the thesis are as follows:

1. Spell out the orthodox scientific image of time
2. Show how this is in apparent tension with our manifest image.
3. Assess notable recent proposals from Lee Smolin (and others) to amend physics to solve the tension.
4. Suggest a different metaphysical starting point for a path forward.
5. Develop this path forward by integrating a particular cognitive account.
6. Show how this approach solves many of the apparent tensions using the broader philosophical framework of perspectivalism.
7. Show how this approach can shed light on and be applied to issues in other domains.

The chapters of the thesis are laid out as follows. Chapter 1 is intended to be a first-pass introduction to the central tensions regarding understanding the status of time within analytic philosophy. Chapter 2 will discuss issues in understanding how we approach some of the aforementioned tensions from the point of view of the fundamental physical sciences. In particular will be an evaluation of recent work by Lee Smolin who proposes radical revisions to orthodox approaches in fundamental physics. Chapter 3 will propose a novel metaphysical approach to approaching the problem of TF through the application of Neural Monism. This chapter will also begin to foreshadow many of the themes in later chapters regarding the perspective aspects of the account. Chapter 4 will then build up an explicit psychological frame-

[35] Notably in Chapter 3.

work for accounting for our experience of the flow of time. Chapter 5 will situate the previous work into the contemporary philosophical tradition of perspectivalism and show how this can resolve the dialectical tension presented at the start of the thesis. The penultimate Chapter 6 explores various applications of the account presented with direction for further research, both empirical and philosophical. Finally, Chapter 7 concludes by summarizing the key findings presented in this thesis.

Chapter 2

Objective Flow

> I conclude that the problem of the reality and the determinateness of future events is now solved. Moreover, it is solved by physics and not by philosophy. We have learned that we live in a four-dimensional and not a three-dimensional world, and that space and time or, better, space-like separations and time-like separations-are just two aspects of a single four-dimensional continuum with a peculiar metric which sometimes permits distance $(y, x) = 0$ even when $x \neq y$. Indeed, I do not believe that there are any longer any philosophical problems about Time; there is only the physical problem of determining the exact physical geometry of the four-dimensional continuum that we inhabit. (Putnam, 1967, pg. 247)

The above quote from Putnam is a striking remark on the purported impact that the study of physics can have on the field of philosophy. It is indeed true that there has been a long and productive exchange between physics and philosophy, particularly in the late 20$^{\text{th}}$ century and early 21$^{\text{st}}$ century. However, in this chapter, I will argue that Putnam goes too far in the above claims. Not only are there plenty of open philosophical problems about time, but that even within physics and especially in contemporary work in foundations of Special and General Relativity and Quantum

Mechanics, there is still a great deal of conceptual work to be done around the concept of time.

In Section 2.1 I will briefly outline the now old-school way of modeling time from a Newtonian spacetime. This will provide a foil for Section 2.2 in which I will outline the now orthodox account way in which General Relativity (GR) complicates our view of spacetime as Putnam eludes to in the above quote and discuss some outstanding philosophical puzzles that GR presents us with. In section 2.3 I will examine the work of Lee Smolin as a case study of a particularly novel approach to addressing many of these aforementioned puzzles posed by contemporary physics. Finally in Section 2.4 I will compare and contrast Smolin's work with two other accounts of Quantum Mechanics (Relational Quantum Mechanics and QBism) that attempt to address several issues overlapping with Smolin's program. Finally, in 2.5 I will begin to sketch the positive alternative that will be built upon in this thesis of how we are to understand our experience of time within the context of our physical theories.

2.1 Newtonian Time

The discussion of the scientific image of time often begins with Newton's absolute time. There is a sense in which this Newtonian account matches up with parts of our manifest image of time articulated in Chapter 1, most notably absolute simultaneity. This is a result of the euclidean geometry of Newtonian spacetime which maintains a unique foliation, where a foliation refers to a particular configuration of 3 dimensional 'slices' or hyperplaces of a 4 dimensional spacetime. What is attractive about absolute simultaneity is the potential for an objective shared global present. The relative magnitudes between these present moments do not depend on one's coordinates or reference frame.[1]

[1]There is a detailed literature on the distinction between absolute (or substantivalist) vs relational views of spacetime going back to Newton and Leibniz. While this distinction will be discussed later in this chapter it is worth noting here that when setting up the distinctions between Newtonian and Relativistic spacetimes, we can be agnostic with respect to whether we treat

As also mentioned in Chapter 1, absolute simultaneity straightforwardly permits many of the A-theoretic metaphysical interpretations, since they only need to identify one such simultaneity slice as a privileged present and the spacetime structure facilitates the work of distinguishing an objective past, present and future. So for a presentist view one might think that Newtonian spacetime is a modeling device that models changes in the present, or a possible history, while not necessarily representing existing entities. For a Growing Block view, one might use the distinction of objective past and future as a metaphysically distinction such as actual vs possible. For a Moving Spotlight view one might use the objective foliation as candidates for the 'size' of the spotlight as it sweeps across the block. We can then think of the flow or passage of time as an objective mind-independent fact regarding how the objective present changes.

On the other hand, the B-theory seems equally supported by a Newtonian spacetime which does not *necessitate* a privileged present, rather it permits it if one is committed to one. So, as it stands, considering the structure afforded by Newtonian spacetime alone, the A and B theories seem equally plausible. Whilst the theoretical device of a unified 'spacetime' is convenient in a Newtonian picture, it is in principle possible to separate space and time as nevertheless conceptually distinct. This tends to work again perfectly consistently with A-theoretic accounts of time, since time and space are similarly treated as conceptually distinct. Nevertheless, as it stands the structure of Newtonian spacetime is not sufficient to convincingly adjudicate on the metaphysics of time.

However, we now know that the geometry of our world is almost certainly *not* euclidean, but instead the hyperbolic geometry described by the Special and General theory of Relativity. Lets now review some of the challenges that these contemporary spacetime theories present to the philosophy of time.

spacetime as absolute in either case.

2.2 Einsteinian Time

There are three key challenges from stemming from our most contemporary physical theories that put pressure on the task of incorporating something resembling temporal passage, which may result in something resembling our experience of TF into such physical theories.

The first of these challenges, shared with the previously discussed Newtonian view, is that the laws of general relativity (and quantum mechanics) are time-reversal symmetric. One of the ways of stating what time-reversal symmetry is, is when performing the mapping $t \to -t$ generates another solution of the equations of motion.[2] This fact seems like evidence against the reality of passage, since there is at least a strong intuition that says that passage surely demands a preferred direction in which such passing occurs. This seems necessary for us to say that time flows *towards the future*, as opposed to towards the past, or who knows where. Yet our current best fundamental physical laws seem to impose no such intrinsic direction of time. A direction of time then seems to only appear as a statistical feature of the world provided by statistical mechanics.[3]

The second feature is surely the most salient one which motivates most philosophers who believe in the unreality of objective becoming, passage or flow, that is the Block interpretation of special relativity.[4] Here the problem stems from the relativity of simultaneity which, unlike the Newtonian view, makes facts regarding which moments are simultaneous, and hence which moments are co-present, observer dependant. If we accept this connection of simultaneity and co-presentness (along with co-presentness being transitive) we get the famous Rietdijk–Putnam argument which concludes that all events are co-present with each other.[5] As Penrose puts it

[2] See Roberts (2021, 2022) for detailed treatments of time-reversal symmetry.

[3] See Albert (2000) for an influential account of how one recovers a preferred direction of time from fundamentally time symmetric laws.

[4] While the block view originates from special relativity, the argument is also extended to general relativity.

[5] See Dorato (2008) for a critical analysis of Putnams argument, concluding that it does not have the purported force in denying ontologically non-eternalist views.

"It begins to seem that if anything is definite at all, then the entire space-time must indeed be definite!" (Penrose, 1999).[6]

The third and most distinctive challenge that puts pressure on manifest features of time appearing in foundational physics is unique to General Relativity which treats time as a Gauge Parameter. This is often refereed to as *the* Problem of Time in modern physics.[7] which arises when going from the Special to the General theory of Relativity (GR). There are broadly two facets to the Problem of Time that both arise from the more elaborate formalism of General relativity, the first is from classical GR while the second is a consequence of initial work in canonical quantum gravity—though it also arises in many other approaches to quantum gravity that demand diffeomorphism-invariant observables.

The first facet is in large part due to how general covariance is implemented in GR. Specifically, the diffeomorphism invariance of the theory results in the fact that the transformation of time evolution becomes a gauge transformation. If we take the orthodox view of gauge transformations, that they represent non-physical transformations (i.e. motion along a gauge orbit), then we arrive at the seemingly paradoxical conclusion that temporal labeling is physically meaningless. This can also be viewed from the perspective of observables which, in general relativity, must be diffeomorphism invariant. Clearly, if time is an example of a diffeomorphism, then observables must not change over time, leading to the so-called *frozen formalism*.

The second facet is the fact that time does not appear in the fundamental variables

[6]Einstein himself is, of course, usually taken to have believed the block picture. But as Carnap (1963) noted,

> Einstein said the problem of the Now worried him seriously. He explained that the experience of the Now means something special for man, something essentially different from the past and the future, but that this important difference does not and cannot occur within physics. That this experience cannot be grasped by science seemed to him a matter of painful but inevitable resignation. So he concluded 'that there is something essential about the Now which is just outside the realm of science.

.

Hence, it is possible that he saw in physics an incompleteness in addition to his more well-known qualms with quantum mechanics and its apparent denial of the the observer-independent world. This thesis will attempt to alleviate some of Einstein's worry, albeit maybe only a little.

[7]For detailed, in-depth discussions of these issues, particularly in the context of quantum gravity research see Isham (1993), Rickles (2006) and Anderson (2017).

of quantum gravity. This is efficiently encapsulated in the Wheeler-Dewitt equation $\hat{H}\Psi = 0$ which arises out of quantum cosmology. The Wheeler-Dewitt equation can be straightforwardly contrasted with the time-dependant Schrodinger equation $\hat{H}\Psi = i\hbar\frac{\delta}{\delta t}\Psi$ which necessitates a background time parameter, whereas the vanishing Wheeler-Dewitt equation does not. However, this does not thereby imply that time is a subjective notion. Rather, it is something that emerges from the basic degrees of freedom, namely it is a relative quantity (since relative quantities are immune to the changes generated by diffeomorphisms), for example arising from the structure of point-coincidences of events.[8]

2.2.1 Objections and replies

One straightforward objection against the challenge of time symmetry is to argue that the laws we currently have aren't fundamental and to posit further fundamental laws that are in fact not time symmetric. This would be principally motivated by certain accounts of quantum mechanics or quantum gravity, which (at least under some formulations) introduces time asymmetry in the formalism. Those might be objective quantum collapse like in some interpretations of quantum mechanics or some fundamental notion of causality such as in Casual Set Theory. Nevertheless, irreducible notions of time direction is not necessary since other accounts such as Many Worlds or Relational Quantum Mechanics[9] employ analogous approaches to classical statistical mechanics to resolve the time asymmetry.

Regarding the Rietdijk–Putnam argument there are several objections that one can make to recover some notion of the privileged present. In the spirit of letting the spacetime geometry guide our concept of time as we did in the Newtonian case, one analogous feature of Minkowski is the *lightcone* structure. Given that this structure is not relative to an observer it seems like the natural place to locate some objective notion of the present. However the presentist immediately runs into

[8] For an deeper discussion of these issues see Rickles (2016).

[9] I will examine RQM in more detail in Section 2.4

various issues. The fist can be seen by examining an approach by Howard Stein (1968, 1991) who instead of attempting to define a a notion of *becoming* relative to a given spacetime point. Instead of distinguishing events that are definite and open with respect to a plane of simultaneity (like in Newtonian spacetime) instead it is done by distinguishing past and future light cones such that events in the past light cone are definite and those in teh future light cone are open. However, the cost one pays for this approach is that this notion of becoming is only *relative to one spacetime point*. In effect this would mean that if one was at the center of a given lightcone, there would be no other events that are co-present.[10] The theme of *localising* our concept of presentness or becoming in the light of the spacetime structure of SR is a common one with various approaches of recovering our manifest experience of time.[11] I broadly agree with this stance, however I don't think it goes far enough to accommodate the *dynamic* character of our experience, at best it recovers a temporal asymmetry and constraints on our causal influences. This distinctly dynamical feature is the target of the latter chapters of this thesis.

Objection to the fact that time is not a fundamental parameter in quantum gravity has led many to suggest that time (and space) must somehow *emerge* from non-spatiotemporal entities. This is an unsettled issue, however there is a worry of empirical incoherence articulated by Huggett and Wüthrich (2013) who say "if a theory rejects the fundamental existence of spacetime, it is threatened with empirical incoherence because it entails that there are, fundamentally, no local beables situated in spacetime; but since any observations are of local beables, does not it then follow that none of our supposed observations are anything of the kind?" Given that currently none of the quantum gravity proposals (such as Loop QUantum Gravity, (non-)Lattice spacetimes and String Theory) have a fully fleshed out derived structure that can do the job of behaving like spacetime. However Knox (2013) tempers this worry since she reminds us that functional descriptions are ubiquitous in science

[10] See Savitt (2021) for a review of various accounts of A type approaches to time in the light of modern physics.

[11] See Rovelli (2019) for another such approach.

and that spacetime.[12]

2.3 Smolin's Temporal Realism

This section will use the work of Lee Smolin as a case study to examine a specific treatment of some of the issues raised above. Smolin's work spans many decades and many fields, so this discussion is by no means comprehensive of Smolin's career. However my goal is to highlight and critically evaluate some of the recent novel approaches and suggestions that Smolin puts on the table which have not had sufficient philosophical attention regarding the connection between our fundamental physical theories and issues within the philosophy of time.[13]

Before discussing Smolin's work in particular, lets review two other scholars who argue on similar grounds the radical claim that since we cannot identify features of our psychological experience with features of fundamental physics, we ought to introduce those features directly into the formalism.[14] This is a very non-trivial leap to make and has been rightly met with skepticism. Let us briefly consider a pair of these approaches.

Maudlin's Temporalising Space: Instead of representing time topologically (composed of an open set) Maudlin (2010) proposes a Directed Linear Structure as the basis for constructing a spacetime geometry. Maudlin's view is less radical than those found below since it is consistent with the orthodox Block universe picture. It is motivated by questioning whether topological geometry might be the best tool for describing more fundamental, quantum space-time. His goal is to introduce a fundamental directedness into or formal representation of time which is seemingly not present in the usual picture. However as has been previously noted by Price (2011), while temporal directedness may be

[12] For more on spacetime functionalism see Lam and Wüthrich (2018, 2021) & Baron (2020).

[13] Some notable exceptions of philosophical treatments of Smolins work include Price (2013), Read and Le Bihan (2021), Bysh (2022) and Rickles and Rankin (2023).

[14] See Smolin (2015a), Smolin (2020) and Unger and Smolin (2015) for overviews of Smolin's broad philosophical project.

necessary, is not sufficient to fully introduce notions of flow or passage that the authors below advocate. Passage that amounts to a preferred direction has been referred to as 'anemic passage'.[15]

Dowker's Spacetime Atoms: Causal Set Theory (CST) is seen as a means to introducing passage and becoming as part of the interpretive structure of the theory. Dowker explores a specific model of CST referred to as classical sequential growth (CSG) which is a stochastic model of granular spacetime. One of the primary benefits of the CSG model is that the 'birth' of the individual nodes of the causal set provides an "objective correlate of our subjective perception of 'time passing'" (Sorkin, 2007). However, this is rather hard to swallow both on account of this being a Planck scale phenomenon, and because the apparent passage of time in our subjective perception seems not to be of the same kind of this 'birthing process,' but rather is linked to more general changes in the environment. To make the link between theory and experience here certainly requires a more sturdy bridge.[16]

See Wüthrich (2023), Wüthrich and Callender (2017), Forgione (forthcoming) and Arageorgis (2016) for an assessment of how CST can be interpreted through a lens of a Growing Block metaphysics. Whether one views their assessments as 'critiques' or as 'complications' to the Growing Block view I think depends on one's disposition given the they both articulate ways in which characteristic GB statements such as "the past exists" are complicated in CST since there are events within the casual set that remain indeterminate until the causal set is fully grown (Wüthrich, 2023). Another distinctive GB statement that the present is distinguished as the "front" of the GB which is also complicated by CST for much of the same reasons that it was in GR such as there is no preferred foliation of spacetime and so the only reprieve that someone looking for a privileged present within this theory is to look

[15]Refer back to chapter 1 for a discussion of the distinction between robust vs anemic passage.

[16]An analysis by Hudetz (2015) examining the application of Maudlin's framework to casual sets suggests that it is just as fruitful as standard topology in describing the theory of causal sets. However, it may not be necessary as "the theory of linear structures is not more expressive than standard topology."

for so-called local becoming that is observer-dependant. As Sorkin (2007) puts it we have an "asynchronous multiplicity of 'nows' ". To put it lightly, it seems that these complications go against the spirit of the GB view.

Hence, neither approach is convincing on the motivation of incorporating features of our phenomenology of time into the formalism of fundamental physics. Nor am I convinced by the several approaches based on models of quantum collapse. The idea with these is to reestablish a direct mind-world link (similar to the causal-set proposal) by isolating observer-independent transitions (the wave-function collapses) in the physics that will reflect our experience as of flow. The problem with these is that the mechanism for collapse is not itself on stable ground, and there are issues with making such collapse consistent with relativistic principles. Lee Smolin has developed a very different kind of neo-Heraclitean account which I will turn to now. However, like Maudlin and Dowker this account, at least one component of it, also focuses on the nature of the mathematical structures employed in physics, tracing the timelessness in physics also to the timelessness in the abstract representational structures. Lets with these preliminary remarks out of the way let me now address Smolin's work proper.

Smolin refers to his overarching project of reimagining our fundamental physical theories in the light of issues within the philosophy of time as *Temporal Naturalism.* I take his project as having three main threads; (1) opposing the timeless role that our mathematical representation of fundamental laws take, and (2) how this comes to produce genuine novelty and (3) the role and explanation of conscious experience/qualia. Each of these threads, Smolin admits is speculative in their implementation and are more on par with guiding principles than fleshed out theories. Let's start with (1). The lack of any referent of the flow or passage of time in fundamental physics is taken to be a inadequacy in the formalism. A move that Smolin makes here to abandon the Platonic representation of configuration space in favour of a something new. Smolin describes the problem as follows:

> The argument that time is not a fundamental aspect of the world goes like this. In classical mechanics one begins with a space of configurations $\mathcal{C}$ of a system $\mathcal{S}$. Usually the system $\mathcal{S}$ is assumed to be a subsystem of the universe. In this case there is a clock outside the system, which is carried by some inertial observer. This clock is used to label the trajectory of the system in the configuration space $\mathcal{C}$. The classical trajectories are then extrema of some action principle, $\delta I = 0$.
>
> Were it not for the external clock, one could already say that time has disappeared, as each trajectory exists all at once as a curve γ on $\mathcal{C}$. Once the trajectory is chosen, the whole history of the system is determined. In this sense there is nothing in the description that corresponds to what we are used to thinking of as a flow or progression of time. Indeed, just as the whole of any one trajectory exists when any point and velocity are specified, the whole set of trajectories may be said to exist as well, as a timeless set of possibilities.
>
> Time is in fact represented in the description, but it is not in any sense a time that is associated with the system itself. Instead, the t in ordinary classical mechanics refers to a clock carried by an inertial observer, which is not part of the dynamical system being modeled. This external clock is represented in the configuration space description as a special parameterization of each trajectory, according to which the equations of motion are satisfied. Thus, it may be said that there is no sense in which time as something physical is represented in classical mechanics, instead the problem is postponed, as what is represented is time as marked by a clock that exists outside of the physical system which is modeled by the trajectories in the configuration space $\mathcal{C}$. (Kauffman & Smolin, 1997, p. 118)

In summary, given that we can fully characterise the dynamics of a system using a configuration space representation, a purportedly essential aspect about time that has been lost. However, here Smolin views his project not simply as putting time back into physics; he also wants a new view of mathematics that is also naturalist. The two are thus deeply entangled, with mathematical naturalism and temporal naturalism understood as codependents. One of the ways in which Smolin attempts to abandon the use of timeless mathematics is his suggestion that cosmological dynamical laws themselves are not immune to the flow of time. For this to be the case the laws themselves must evolve somehow. In other words, Smolin's goal is to escape the aforementioned configuration space realism. This is motivated by the Principle of Sufficient Reason targeted toward the explanation of fundamental laws (as Smolin puts it, our cosmological theories should give an answer to the question "why these laws?''). Several well known cyclic cosmological models provide candidates for this kind of evolution. As we will see below, an analogy with biological evolution is drawn to give an explanatory framework for understanding how this may reproduce the physics we observe.

An immediate objection one has towards this approach of removing the timeless cosmological laws by allowing the laws themselves to evolve, is to ask "by what law do the cosmological laws evolve with respect to?". As previously mentioned there are cosmological models that allow for the evolution of the constants/laws. However the form those models take are precisely the form that Smolin wants to avoid, timeless representations. Which would seem to reintroduce timeless, higher-order laws that undermine the approach of evolving laws. Smolin does not provide a definitive answer to the problem of how higher order cosmological laws may escape the problems of timelessness. However, he gestures to the idea of interpreting the metaphysical character of mathematics, not as platonic, timeless objects, but rather as objects that are *evoked* in some moment of time.

This may initially sound like an epistemological claim about our access to the mathematical nature of the world, but Smolin wants to make this into a metaphysical one. He says that when we evoke mathematical structures we bring something into existence that wasn't there before. Not only that but "Nature has this capacity as well and uses it on a range of scales from the emergence of novel phenomena which are described by novel laws to the emergence of novel biological species which play novel games to dominate novel niches." Though it is not clear what is meant by "Nature" in this case. The goal of this approach, as with Smolin's entire project, is to center the fundamentality of the flow of time in how we understand of the world.

2.3.1 Distinction between Law and State

From this interpretive foundation, how does Smolin proceed? Smolin first claims that our aforementioned standard way of doing cosmology falls to a glaring fallacy. This standard way of doing physics, which he refers to as the "Newtonian paradigm" is summarised as doing "physics in a box"[17]. Smolin's intuition here is that since our standard formalism for describing physical systems implicitly assumes an external environment/clock/observer, and the whole universe is precisely that which we cannot have an external perspective on, then it follows our description of it using the Newtonian paradigm is fallacious. Hence, the interpretation of the Newtonian way of doing physics (namely, trajectories in configuration spaces) is then taken to be merely summarising records of past observations of *subsystems* of the universe. They are not to be in "isomorphism [with] the natural world".

Smolin suggests that when doing this new cosmology, the usual approach forces us into a timeless conception of the laws. His proposed solution is that the distinction between physical states and governing laws breaks down such that the distinction becomes only an approximation when describing subsystems. He provides a toy matrix model as a proof of concept for such an approach in (Smolin, 2015b). However in the very same article he says to realise this model one must "embed the configuration space of states, $\mathcal{C}$ and the landscape parameterizing laws, $\mathcal{L}$ into a single meta-configuration space, $\mathcal{M}$." Which brings us back to a timeless configuration space, seemingly defeating the purpose of the model in the first place.

[17]Counterintuitively, "Newtonian" is in this case not meant to refer to classical physics, since Smolin wants to include standard quantum mechanics under this label

Expanding on this idea, Smolin suggests that the higher order 'metalaw' may be part of a large equivalence class, each of which performs the function of a metalaw out of a kind of necessity. He conjectures that "any metalaw which could serve as such is equivalent to any other." (Smolin (2015b)) This, along with some natural assumptions, Smolin conjectures is what would determine the evolution on $\mathcal{M}$ in the previous paragraph. This is intended to be analogous to biological evolution, where the fitness function that defines the evolution of species is itself subject to evolution as the environment changes.

Curiously, Lee Smolin also invokes a formulation of GR referred to as Shape Dynamics (SD) primarily developed by Julian Barbour (2003, 2012). Smolin argues that SD contains a candidate for a privileged present that is nevertheless consistent with the results from classical GR. This is the case because Shape Dynamics was shown to be equivalent and, in fact, a dual representation of classical General Relativity (Gomes et al. (2011) and Gomes and Koslowski (2012)). What shape dynamics tells us, as Gryb and Thébault (2016) put it, is that our classical description of gravity is *Janus-faced*: there is an underdetermination of the symmetries of classical gravity, such that it admits these different descriptions with different accompanying temporal ontologies. One with a privileged, global present (and a distinguished slicing of spacetime into 3-spaces), and one without (with relativity of simultaneity resulting from foliation invariance).(Rickles, 2017)

How does shape dynamics provide a privileged present? Starting from classical general relativity we can employ a procedure of *symmetry trading* such that we trade the foliation invariance of Einsteinian general relativity for the invariance under spatial conformal transformations. Physically, this means that the relativity of simultaneity is 'traded' for the relativity of size, resulting in an empirically equivalent but ontologically distinct theory. This results in a preferred foliation of spacetime along hyperplanes of *constant mean curvature* (CMC). Smolin argues that relativistic spacetimes that admit foliation along such hyperplanes does not fall prey to the problems he sees for Newtonian absolute simultaneity since "the CMC is a dynamical condition so that which slices satisfy it depend on the distribution of matter, energy, and momentum throughout the universe" Unger and Smolin (2015, pg. 387).

The issue Smolin faces, as we will see below, is that shape dynamics not only does not meet all of his ambitions for a new cosmological framework but also needs further justification for its use over other formulations of GR. One of those issues being that since Smolin aims to rid physics of any timeless, Platonic mathematical representations, this immediately poses a problem when adopting shape dynamics as a candidate for capturing the privileged present. Namely, that it is precisely because of the underdetermination of the formalism that makes either representation *as good as the other*. We have no positive reason, all things being equal, to choose one representation over the other. Smolin's move here is to invoke further motivations to justify such a choice. As Rickles puts it "when we have (genuine) dualities apparently holding between a pair of theories, we ought not to take either picture as fundamental or (entirely) physical. [...] Thus, any interpretation we give is 'provisional,' and points towards some common core" (Rickles, 2017).

The theme of dual representation is one that has a rich history in physics and is one I wish to build on with our approach to understanding the complete nature of time. As I will argue in later chapters of this thesis when discussing dual-aspect monism, and later when discussing perspectivalism, the purported tension between competing images of time arises from ultimately compatible dual representations of a single underlying entity.

2.3.2 Novelty

The next primary motivation of Smolin's project is to introduce genuine novelty into fundamental physics. This is seen to be the means by which we can escape the platonic representation of mathematics and recover notions of flow and genuine temporal becoming. This motivation is more aligned with the results of quantum mechanics than general relativity and informs the larger project of formulating quantum gravity.

Smolin proposes an extension to a real ensemble interpretation of quantum mechanics (Smolin, 2012b) that he refers to as the "Principle of Precedence." The ensemble interpretation ascribes a certain frequentist flavor to the probabilities of quantum measurements. Namely, that the outcomes of quantum measurements are sampled from the ensemble of all previously identically prepared states. The Principle of Precedence goes one step further and claims that if a quantum state has no precedent in the history of our universe, its outcome is not determined by any prior law (Smolin, 2012a; Unger & Smolin, 2015). Intermediate states, with only few precedents have their outcomes "maximally free" in the sense defined by Conway and Kochen (2009) such that the outcomes of experiments can't be predicted by knowledge of the past. This turns out to be a highly non-local approach, since the state needs to "know" if there has been a precedent state, requiring some access to all prior states of the universe at once. This leaves room for genuine novelty of outcomes to arise for states without precedent while nevertheless respecting existing deterministic laws for states with established precedent. This interpretation invites a kind of possibilism, or "growing block" picture, as opposed to a standard presentist picture due to the asymmetry in Smolin's characterisation of the past and the future in a way that is dissimilar to a standard presentist.

2.3.3 Qualia

The last key motivation for Smolin's project is dissatisfaction with the fact that an explanatory story for consciousness is seemingly missing from the orthodox picture of the world provided by physics. Notably he raises objections towards the block universe picture provided by relativity. Specifically his characterisation of the physicists conception of the block, as he puts it; "assumes that the universe's history is the result of deterministic and immutable laws acting on initial conditions, and this is what I will refer to when I speak of the block universe." (Smolin, 2015a) While Smolin is more ambivalent towards what he calls the "philosopher's block" which is characterised as the set of events that are the case if we let the entire history of the universe play out. He sees this picture as at least compatible with his project, if irrelevant. His main objection stems from his claim that consciousness/qualia "allow the presently present moment to be distinguished intrinsically without regard to relational addressing." (Unger & Smolin, 2015, pg. 482) From this starting point he presents an interpretation of quantum mechanics to address this problem.

Trying to provide a solution to the hard problem of consciousness and qualia that takes advantage of quantum mechanics is a well-worn strategy. The intuition is that quantum mechanics is mysterious, consciousness is mysterious, maybe we can kill two birds with one stone.[18] Smolin has such an ambitious proposal that is tied to the Principle of Precedence introduced above.

Smolin suggests is that it may be precisely those states without precedence that produce, or are correlated with qualia. It is plausible that each physical state a given brain finds itself in has not been reproduced at any previous instant in our universe and hence are without precedent. This approach would be most closely mapped onto a panpsychist approach to consciousness, and would only ascribe qualia to sufficiently complex states. However, there are several places where Smolin's panpsychism is idiosyncratic. The first is how he describes qualia as "intrinsic" in a way very different to how other panpsychist philosophers would use the term. "Intrinsic" in the philosophical sense is used to describe aspects of the world that are not captured by the dynamical description,[19] but Smolin lumps energy and momentum together as "intrinsic" to matter. What Smolin has in mind when talking of intrinsic properties is in contrast to relational properties. He is ambiguous on the dynamical nature of qualia, just that the word "intrinsic" should encompass both dynamical and internal aspects of matter.

It is also the case that the Principle of Precedence as an explanatory framework for consciousness inherits the usual objections to panpsychism such as the combination

[18]See Cortes and Smolin (2021) for more explicit discussion of this kind.
[19]Which is precisely why panpsychism is attractive to the naturalistic inclined.

problem. This is the problem of how do individual micro-scale conscious entities combine to produce a single unified macro-scale conscious entity. If the precedence of states are defined with respect to their wave function, then it's not clear how the decohered wave-functions of macroscopic systems (like our brains) are carved up into one unified conscious perspective. Particularly given that brains like ours are macro-scale decohered systems[20] where a classical functional description seems sufficient, unless a positive account of how such quantum effects can shed light on such effects it not clear what is gained by employing it. Smolin himself touches only briefly on the connection with pansychism (Unger & Smolin, 2015) leaving much room for further analysis.[21]

The onus is on Smolin to articulate our capacity to represent an objective/unique present vs representing an indexical present. The latter is less controversial while the former is dubious.[22]

2.3.4 Summary

Smolin's project is an ambitious one with many disparate ideas brought together with the aim of solving many disparate puzzles. This makes an effective summary difficult. However the driving motivation for the project is clear. The conceptual basis of time in fundamental physics requires re-imagining. This is in part due to the larger project of constructing a coherent theory of quantum gravity and also due to foundational concerns in explaining consciousness within our physical theories Myrvold and Christian (2009, p. 466). One obvious response to Smolin's demand for finding a place for time at a fundamental level is that it comes from experience, and yet that experience is severely limited. We cannot boost ourselves into frames

[20] There are proposals that suggest that entanglement might be involved in some small scale brain processes and that that might give room for quatum effects to make a difference in our cognition, notably by Hameroff and Penrose (1996) but such proposals are highly speculative and haven't born out

[21] See Dainton (2023a) for a recent discussions of the complications of how pansychism fits in with modern physcics.

[22] I will discuss the so-called 'detector argument' by Prosser (2016) in latter sections which argues against our ability to represent an objective present/passage. Also see Braddon-Mitchell (2004) for a critique of the growing block view on these grounds.

near the speed of light, so our experience cannot encompass such regimes. This is why we are led into physics in the first place, to supplement our limited range of experience. Moreover, it is clear that human time involves a large constructive component. This underpins much of our experience of time, and indeed, albeit in a small way, our experience can be modified somewhat. What does this fact tell us about reality? If our experience of time is constructed in various ways, is it legitimate to use this to inform a conception of time in the universe, as Smolin and others suggest? After all, what Smolin means by "temporal qualia" is simply temporal phenomenology. Until we have established the extent of the brain's role in this, we might be wise to withhold making too quick inferences from such temporal phenomenology to the reality of temporal passage.[23]

Nevertheless there is plenty to be sympathetic about regarding Smolin's denial of a block universe picture. Several results regarding the infamous Wigner's friend thought experiments (Bong et al., 2020; Brukner, 2018) have shown that if we take quantum mechanics serious it seems to deny the joint combination of statistical independence, locality and absoluteness of observed events. However, much like philosophical accounts of presentism managing to cunningly make peace with special relativity, there are ways to make peace with such results on a Block universe view.[24]

2.4 Relational Quantum Mechanics and Qbism

Two other notable accounts stemming from quantum mechanics are Relational Quantum Mechanics (RQM) advocated notably by Carlo Rovelli and QBism advocated by Chris Fuchs.[25] These two accounts provide notable contrasts to Smolins

[23] Characterising the brains, and more generally the agent's, role in our experience of TF is the task of the upcoming chapters of this thesis.]

[24] For example, a block universe view is perfectly compatible with non-locality, so a philosopher can happy choose to dismiss this feature of our universe, even if it might keep physicists awake at night.

[25] Whilst QBism originally began as a portmanteau of Quantum Bayesianism, Fuchs has since stressed its should be thought of as a more specific approach to quantum theory since many other approaches have since incorporated Bayesian notions. (Fuchs, 2017a) Fuchs also mentions a comment from David Mermin who likens QBism to Cubism (the artistic movement), which I take to be a particularly apt comparison since both attempt to represent the world from various

view, not only as interpretations of quantum mechanics specially but also in the way in which they address some (though not all) of the concerns that Smolin raises regarding the nature of time.

Given its name, its unsurprising that one of the distinctive features of RQM is how it emphasises the *relationality* of quantum systems. Specifically it does so by answering the question; "When and how a probabilistic prediction about the value of a variable a of a physical system S is resolved into an actual value? The answer is: when S interacts with another physical system S'. Value actualization happens at interactions because variables represent the ways systems affect one another [...] The actualization of the value of a is such only relative to the system S'. The corresponding state ρ' determined by the actualization is therefore a state relative to S', in the sense that it predicts only the probability distribution of variables of S in subsequent interactions with S'. *It has no bearing on subsequent interactions with other physical systems*." (Rovelli, 2018).[26] From this statement we can see the emphasis on *interactions* as the primitive ontology of the theory.[27] This is sometimes referred to as a 'flash' ontology which evokes a collection of individual flashes of determinate properties in the fog of indeterminacy. Dorato (2013) describes RQM

RQM implies similar conclusions to Smolin's critique of the so-called Cosmological fallacy in which both imply that given that there is no stepping 'outside' the universe, there is no meaning to the 'state of the universe'. This emphasis on relationlity on both Rovelli and Smolin's part is not accident since it stems from their shared background working on Loop Quantum Gravity.

QBism is similar in spirit to RQM with some notable .As a first brush of characterising QBism is interpreting the formalism of quantum mechanics *epistemically*, that the formalism represents an particular agents knowledge of systems rather than rep-

conflicting individual perspectives.

[26]For critical assessments of RQM see van Fraassen (2010) and more recently by Muciño et al. (2022).

[27]See Oldofredi (2021) for a discussion of how RQM can be made compativel with a moderate version of structural realism.

resenting physical systems directly.[28] QBism is intentionally very agnostic to what quantum theory might tell us about what we might want to call 'the world' independent of observers. Fuchs (2017b) tentatively suggests that the Born rule provides some structural description (analogous to the kind used in structural realism) of the world, with irreducible worldly chanciness.

Fuchs (2017b) coins the term *participatory realism* to describe the picture that QBism presents us with.[29] Focus is placed on participants *co-creating* the world by making choices regarding questions to ask through the relevant kinds of probes, with the world generating appropriate answers.[30]. This emphasis on the first-person, relative, observer dependency puts pressure on a strict block universe view since "reality is *more* than any third-person perspective can capture." Fuchs (2017b)

Pienaar (2021) provides a very useful comparison of these two frameworks. Despite their many similarities, such as taking measurement to be fundamental, the *meaning* they ascribe to the process of measurement is different. While RQM takes measurement to be the result of any kind of physical *interaction*, QBism takes measurement to explicitly be the result of the actions of an *agent*. This seems to implicitly tie experience and decision making into a quantum mechanical measurement in such a way that inanimate objects would not qualify for.

One key difference that Pienaar (2021) discusses is how QBism treats laws as *normative* rather than (say) describing necessary connections/dispositions between events (cf. (Fuchs, 2017a)). It is normative in the sense that it describes the kind of rational expectations that agents ought to follow. This is in contrast to RQM (along with most other approaches to quantum theory) which are law-like, insomuch as it "does not see the laws of quantum theory as being optional or specific to decision-making

[28]See **fuch s2017participatory**; Fuchs et al. (2014), Fuchs and Peres (2000), Fuchs and Schack (2014), and Mermin (2017) for overviews of QBism.

[29]This terminology has roots in the work of John Wheeler (1981) in formulating his now infamous catchphrase 'It from Bit' which emphasises how "every **it** — every particle, every field of force, even the spacetime continuum itself — derives its function, its meaning, its very existence entirely — even if in some contexts indirectly — from the apparatus elicited answers to yes or no questions, binary choices, **bits**." (Wheeler, 2018)

[30]See Atmanspacher and Rickles (2022) for a philosophical treatment of these views in the context of dual-aspect monism.

agents, but rather sees them as universal natural laws governing the production and interactions of physical information". This distinction is not intended to track along Humean/anti-Humean views of laws which distinguishes whether natural laws are merely efficient *descriptions* of the world or whether they have some extra ontological status on top of mere description. However the normative status of QBism is distinct from both Humean and anti-Humean approaches in that in both of the latter cases the laws are *about*, or *refer to* states of the world. This is contrasted with the normative account in which the laws of quantum theory are *about* how agents degrees of belief rationally change given some quantum system.[31]

Rovelli's *thermal time* hypothesis (Martinetti & Rovelli, 2003; Rovelli, 2011, 2013; Rovelli & Smerlak, 2011) is an attempt to break the time symmetry provided from GR and RQM and provide a linear ordering by defining a thermal clock to be precisely one whose pointer reading moves linearly with respect to Hamiltonian flow. This, is a statistical concept, so Rovelli denies the fundamental status to time that Smolin wants, though he provides a proposal for its emergence: time is that variable that in some sense simplifies the description of the macro-system. His relational approach also has a similar flavor, in which time is extracted from the physical degrees of freedom of the theory of loop quantum gravity. Again, the source of this viewpoint lies in the interpretation of space and time coordinates as gauge degrees of freedom (Rovelli calls them "partial observables") that need to be fixed by physical degrees of freedom, in this case relative quantities ("complete observables") involving relations between partial observables (e.g., one can define an instant of time using a coincidence of the values of a pair of physical fields that while individually are not gauge-invariant, when related like this are gauge-invariant).

While RQM and Qbism offer various solutions to the problems that Smolin points to, they do not solve all of them. Importantly, the apparent dynamic quality of

[31] See DeBrota et al. (2021) for a discussion of how, with minimal assumptions of what counts as a quantum system, if an agent doesn't follow the Born rule then they are vulnerable to the famous Dutch-book arguments that are used to argue for the coherent rationality in standard Bayesian probability.

time that our experience provides us access to is still absent. In my view QBism begins to address this but does not go far enough in specifying the specific kind of agent who's degrees of belief are being described. Now this is arguably intentional on the side of the QBist to provide as general an account of quantum mechanics that is possible. However, if we are in the business of attempting to account for our temporal experience, then more needs to be said about the agent.

2.5 Agential Embedding

The central argument presented in this thesis is that accounts such as QBism, or the proposals articulated by Lee Smolin that employ some notion of local becoming, or objective passage are not necessary to account for our manifest experience of TF. The key missing piece that these accounts miss is the need to provide some kind of mechanism that avoids the so-called detection argument. The argument is summarised as follows; "the brain is of course a physical system. If no physical system can detect the passage of time, then the brain cannot detect the passage of time. And if the mind is the brain, then it follows that the mind cannot detect the passage of time." Prosser (2016, pg. 35) We can interpret the passage of time here as any of the accounts of changing of objective present presented above. Given that our cognitive systems are macroscopic, and the physical models presented above all converge on a shared macroscopic description, this would suggest that there is nothing that could distinguish them as providing a mechanisms by which our cognitive systems could detect such objective accounts of passage, resulting in our experience of TF.

Another reason these accounts fall short in accounting for TF is because they are only physical models and are silent on the kinds of agents that are embedded within them. It's the task of the rest of this thesis that only by spelling out such an agent that we recover the perspectival temporal features that recover our manifest experience of time.

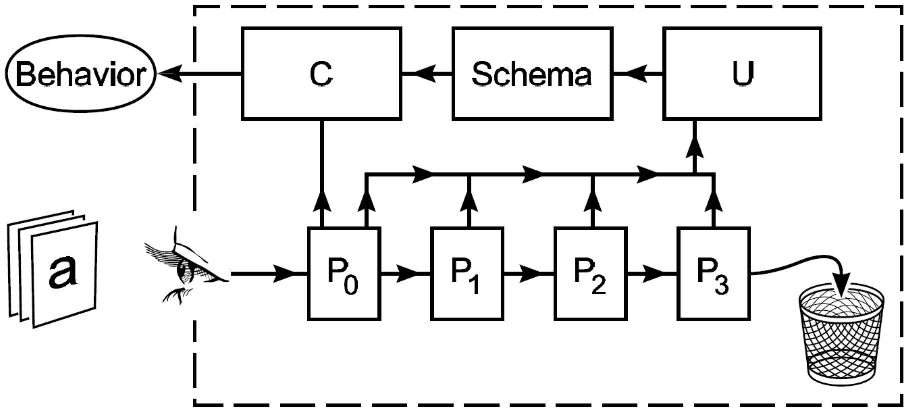

Figure 2.1: A schematic diagram of an Information Gathering and Utilising System (IGUS) by Hartle (2005). Arrows represent information transfer between the various registers with $P_{0,1,2,3...}$ representing memory registers of consecutive events. C and U are meant to represent conscious and unconscious processing with a simplified model or schema of the external environment between them.

This approach of how one recovers a variety of manifest features from this seemingly alien formalism is through understanding the conditions under which a particular agent is embedded in the spacetime manifold. Instead of altering the fundamental formalism to fit with our subjective experience, the thought is that, properly considered, the seeming tensions between our scientific and manifest images boil down to building the appropriate bridge between. One influential account is by Hartle (2005) who describes an Information Gathering and Utilising System (IGUS) seen in Figure 4.1. Hartle's main goal in spelling out the IGUS was to account for how a given agent, with particular capacities, embedded in a particular spacetime, would experience an apparent privileged present that has asymmetric epistemic access to the past and future. This approach has been expanded upon by other philosophers with a particular interest in physics such as Callender (2008, 2017), Ismael (2016a, 2017) and Huggett (2014) in an attempt to account for a wider variety of manifest temporal features in more detail.

This thesis will attempt to contribute to this literature from two distinct directions. From the bottom up and top down, so to speak. What I am calling the bottom up contribution is contributing to the conceptual confusion regarding the nature of what our experience of temporal flow amounts to metaphysically. The top down will be to add to the established literature on spelling out the details the necessary features for a particular agent to experience temporal flow. One such addition to Hartle's IGUS is the deep connection between perception, which is established in the IGUS, and *action* which is comparatively lacking from the model.

2.6 Conclusion

While I am sympathetic to Smolin's motivations and diagnosis of the disconnect between the description of time provided by fundamental physics and that of our subjective experience, where we diverge is in the treatment of how to address the problem. As I will hope to show in the subsequent chapters is that provided an appropriate metaphysical view, accounting for our temporal phenomenology can be done through a careful articulation of how such agents like us are embedded in such an strange fundamental formalism. Only once we articulate such an embedding do the conditions for our temporal phenomenology reveal themselves.

Chapter 3

Metaphysical Flow

3.1 Introduction

One of the primary motivations of this chapter is to address Temporal Flow's (TF) conceptual *slipperiness*. How it is difficult to put into words what such an experience even points us towards. Its difficult to even get a grip on what the experience amounts to without resorting to vague gesturing[1] or otherwise characterising it in relation to the metaphysically loaded concept of *temporal passage*, which was covered in Chapter 1. In this chapter I will be agnostic as to the relationship (or lackthereof) of TF and temporal passage. In lieu of this, theoretically agnostic descriptions tend to resort to talking about such experiences is through metaphor and analogy[2]. These concepts then also define themselves with respect to, or in opposition to others rather than providing a strict positive definition. As will later argue in detail, the reason for the non-specificity is in part due to the fact that TF, unlike other temporal features is not straightforwardly incorporated into the conceptual framework of our standard scientific physical theories, and hence does not have the luxury of drawing upon the conceptual resources to characterise it. However with sufficient work I argue is can

[1] A common example of such gesturing involve descriptions of TF as the 'woosh' of conscious experience accompanied by suggestive hand-waving.

[2] The very word "flow" is indeed such a metaphor, drawing on our image of a river. See J. Smart (1949) for an analysis.

be incorporated.

Given that TF is a notorious concept in the philosophy of time, this chapter will be an attempt to begin the analysis of TF from a different direction to the usual accounts. This is because one of the primary challenges facing our understanding of TF is properly articulating what is even meant by it in the first place, since very often our descriptions of TF rely on vague appeals to metaphor or intuition.[3] This chapter aims to provide a conceptual foundation to help solving this problem that is different from the usual approaches in the literature by analysing TF *qua* phenomenon. The term "phenomenon" is a technical term of art within a variety of fields of philosophy and in fact has been used in a variety of contexts to mean different things. Given this, in this chapter I first sketch out two broad ways in which the term phenomenon has been understood. These two ways in which the concept of phenomenon has been used, particularly in science, sheds light on a certain tenacious dialectic that I will argue neither side of which is able to account for TF. In response to this dialectical roadblock an alternative conception of phenomena will be presented in the pairing of Neutral Monism (NM) with epistemic structuralism. I will argue that accounting for TF with the tools provided by this pairing results in the best of both accounts of phenomena, which builds towards a fuller account of TF as a perspectivalist feature which will be developed further in later chapters.

Section 3.1 was a brief introduction to the problem of characterising TF and a motivation of using the concept of phenomenon to further elucidate TF. In Section 3.2 I will sketch out the two broad ways in which the term "phenomenon" has been understood, broadly as either objective features of the world, or as features of our subjective experience. In Section 3.3 I apply each of these ways of understanding phenomena to see how they each might characterise the phenomenon of TF. In the end I find that each of them lacking in their articulation of the nature of TF for various reasons. For those committed to the reality of the phenomenon of TF, in Section 3.4 I tentatively suggest a resolution to this objective-subjective dialectic

[3] Even the standard terminology of *flow* and *passage* stem from metaphors.

might be found in adopting NM and suggest reasons why the phenomenon of TF might have the potential to be well-formulated in such terms.

3.2 Which kind of Phenomenon?

The term "phenomenon" has a long history, which results in it having various associations that need to be teased out. I will not be delving into the history, only to point out that there are two broad ways in which the term has been characterised. The first is in terms of pointing to features of *experience* (hence, *phenomen*ology), let's call this characterisation *subjective phenomena*. The other is in terms of effects, processes or events *in the world*, lets call this *objective phenomena*. The terms subjective/objective here are not intended to signal a difference in metaphysical primacy or significance, as we shall see each is associated with a different underlying metaphysics therefore, the terms subjective/objective are simply intended to point to how each of them are grounded, either by subjects or objects in their respective metaphysics. As such, each characterisation will come with a different notion of realism with respect to the products of scientific inquiry. A consequence of this is that depending on one's approaches to characterising phenomena, the fact that our experience of flow is grounded in subjects need not mean that it is 'emergent' or 'illusory' as it is often claimed.

3.2.1 Objective Phenomena

Hacking (1983) describes the objective characterisation of phenomena and makes a point to stress their "public" nature. That it "must be kept as separate as possible from the philosophers' phenomenalism, phenomenology and private, fleeting, sense-data" (Hacking, 1983, pg. 222). This characterisation is generally the way in which it is employed in the sciences. A similar characterisation can be found in the writings of Niels Bohr in which he stressed the results of experiments should "refer to a situation where we can tell others what we have done and what we have learned and that, therefore, the account of the experimental arrangement and of the results of the observations must be expressed in unambiguous language"(Favrholdt, 1994). The point here is that a key feature of phenomena in this characterisation is their inter-subjectivity, whether through language, or through mutual observation.[4][5]

A characterisation of objective phenomena proposed by Falkenburg (2011) following on from Hacking (1983) are said to satisfy the following criteria:

I. Spatio-temporally individuated objects and events in the world, i.e., **concrete**;

II. Given by observation or measurement, i.e., **empirical**; and

III. Explained in terms of laws and causal stories, i.e., **typical, regular**

These criteria seem to be intended to be necessary and sufficient for the classification of something to be a phenomenon, and indeed these criteria match closely with the scientific use of the term (particularly in physics). Modern paradigmatic examples of these these phenomena might include the trails observed in cloud chambers, gyroscopic procession and the interference patterns of lasers.

The relationship that phenomena have to *data* is an important addition to this characterisation of phenomena as a means to describe our epistemic *access* to phenomena. Much has been written regarding the relationship between data and phenomena, particularly with Bogen and Woodward (1988) being an influential account of the relationship between data and phenomena, and J. F. Woodward (2011) with a more recent review. One of the key takeaways from the literature is that no experiment can have direct access to phenomena given by theory, instead we have to construct particular models from the theory and experiments that produce data which reflect

[4]Despite this emphasis on inter-subjectivity, Bohr was famously an instrumentalist regarding the products of physics: "Physics is to be regarded not so much as the study of something *a priori* given, but rather as the development of methods of ordering and surveying human experience. In this respect, our task must be to account for such experience in a manner independent of individual subjective judgment and therefore objective in the sense that it can be unambiguously communicated in ordinary human language."(quoted in Favrholdt (1999))

[5]While this is indeed the way that Bohr is often characterised, the details of Bohr's views are still the topic of academic disagreement. For a recent example of such a discussion, see Evans (2020) who argues that Bohr can be understood in Perspectival Realist terms.

to some feature of the phenomena, but not its entirety.[6] This is the case because there may be other causal influences that influence the data and there will invariably be features of the phenomena that the data do not provide access to.

3.2.2 Subjective Phenomena

The second kind of phenomena that we will be examining are subjective phenomena. In general these are phenomena that are grounded in the experiences of subjects and, broadly construed, the project of science in this approach would be simply to account for the phenomena of experience such as in Bohr's characterisation. The canonical system for the characterisation of phenomena in this way is provided to us by Kant. Here I will provide a brief exposition of the Kantian internalist stance[7] that will be relevant to our discussion. The reason for discussing Kant directly despite much of the philosophical progress that has happened on these ideas is not only because of their deep influence on much of philosophy, but also because there will be several resonances throughout the following chapters that are illuminated with reference to these ideas.

The starting point is to distinguish phenomena and *noumena* (sometimes referred to as 'things in themselves'). While we have epistemic access to the phenomena, we don't have access to the intrinsic nature of objects external to us, their noumena. This is what grounds Kant's Transcendental Idealism, which stresses that the *form* in which objects are given in experience is mind dependent, as opposed to the objects, or things in themselves. From this we are lead toward the distinction between appearances and phenomena.

In the Kantian system phenomena are not synonymous with appearances. To provide the necessary conditions to make sense of, as Kant puts it "mere appearences", one needs to structure said appearances within an a priori categorical framework. Fa-

[6]An example of this would be the data gathered to measure the phenomenon of gravitational lensing by collecting data of the relative positions of stars before and during a solar eclipse.

[7]Here I use *Kantian stance* in the way described by Massimi (2010, 2011), namely as a characterisation of the"human epistemic conditions under which we gain knowledge of phenomena." rather than a strict account of Kant's system.

mously, Kant's proposal for such an a priori framework was partly a spatio-temporal one. So spatio-temporal features of our experiences were not given by experience but instead are the conditions of possibility of our experience, they. This is notable for our discussion since, in Kant's view, the temporal features of both phenomena and noumena are not part of their intrinsic nature, but instead are grounded and provided by intuition. So while appearances are objects given in sensibility, phenomena are *conceptually determined appearances*.[8] We can see already that one of the strong suits of the subjective phenomena account is that it more directly accounts for the mental in a way that the objective account does not.

The choice of Kantian system to characterise subjective phenomena is not one of necessity. Rather, it is worth examining since it is arguably the most influential and paradigmatic example of subjective phenomena that exists in the philosophical literature. However, the goal of this chapter is not to give a comprehensive study, but to sketch out a certain dialectical tension between the subjective and objective accounts of phenomena that may be robust amongst subjective accounts of phenomena.

3.2.3 Recap

Given the above discussion we can take stock and reflect on various standard examples of phenomena and see which of the two characterisations of phenomena they may be examples of. These can be found in Table 3.1. As we can see in the top left-hand cell of Table 3.1 these are phenomena that are uncontroversial in terms of their status as both subjective and objective phenomena. This means that we both have experiential and objective accounts of these phenomena that have some explanatory bridge between them. Each other cell in the table is either lacking in one or both characterisations.

The question now becomes: where does TF lie on this table? There are already various account of TF that propose answers. The most standard account found

[8] See Massimi (2008) for an articulate discussion of this distinction.

	Phenomena_O	Not Phenomena_O
Phenomena_S	Bouncing Balls, Cloud Chamber Trails	Hallucinations
Not Phenomena_S	Length Contraction, Quantum tunnelling	Round Square

Table 3.1: Examples of phenomena that permit characterisations as Objective Phenomena and Subjective Phenomena, only one kind of phenomenon or neither.

in the philosophy of physics literature would be the Eliminativist account of TF which places it in the top right-hand cell. Characterising it not as an objective phenomenon, however it is nevertheless a genuine subjective phenomenon. The top left-hand cell would represent the varieties of Realist accounts of TF in which it has both an objective status alongside of a subjective one. The Deflationist account of TF would place it in the bottom right cell. This account simply denies that there even is such a thing as the experience of TF, hence there is nether a subjective or objective phenomena to account for. The bottom left-hand cell is not a common characterisation of flow as it would entail the objective reality of flow while denying its subjective reality. It seems clear why this is an unattractive position to take since one of the key pieces of evidence for the reality of flow (both objective and subjective) is through experience. However, it is not out of the question that science (particularly the interplay of physics and neuroscience) may point us in such a strange direction.

3.3 Is Flow a Real Phenomenon?

In this section I will apply the above discussion of objective and subjective phenomena to the specific example of TF. This is intended to show how someone committed to the reality of the phenomenon of TF might interpret the plausibility of the reality of the phenomenon in either case. This is not intended to be a full characterisation of the phenomenon, rather an assessment of which characterisation of phenomena would be best suited to the challenge of accounting for our experience of TF.

3.3.1 Objective Flow

In the case of Falkenburg's first criterion, the *concreteness* of the phenomena are satisfied by being "spatio-temporally individuated [...] events in the world". I see no reason why TF could not satisfy this criterion. If we take TF to be a property of events, we can imagine TF as some extra feature over and above the B-theoretic relations between events, then those features would be instantiated at particular spatio-temporally individuated events. Even if we take flow to include relations between events, rather than a property of a single event, this does not change the outcome.

Falkenburg's second criterion of phenomena being *empirical* is where we find our first interpretive wrinkle. Spelled out a bit more, this criterion is taken to mean: 'given by means of observation, measurement, or experiment' (ibid).[9] This is where the realist most directly objects to the phenomenon of flow. "Show me an experimental outcome that demonstrates, or relies, even indirectly, on TF!" they might say. This is indeed a challenge for those committed to the objective phenomenon of flow. We will return to this issue in Section 3.3.1 regarding the potential for the corresponding Data regarding the phenomenon of TF.

Taken in its most general interpretation, however, we in fact do have plenty of empirical evidence for the phenomena, the evidence from our direct experience! What is lacking in this response is that this kind of evidence is not the "public" kind that Hacking and Bohr are after. Much has already been written about the so-called argument from experience regarding extrapolating our experience of TF/passage to objective features of the world. While there are few strong positive arguments for the objective phenomena, it has yet to receive any smoking gun counter-arguments.[10]

[9] This sentiment is closely related to 'Experimental Realism' proposed by Hacking (1984).

[10] See Baron (2017b) for a review and critique of some of the debunking arguments against the argument from experience. Also see Baron et al. (2015) for a review of the argument from experience in light of results in cognitive science.

One might be curious as to the *potential* or *possibility* of finding this kind of public evidence. This is where physical theories have a roll to play to inform what counts as an empirical finding and what does not.

Falkenburg's third and final criterion of phenomena being *typical*, or *regular* also presents an interpretive challenge. Similarly to the second criterion, I take this to usually mean that phenomena ought to be part of the story provided to us by our physical theories. In this sense the objective phenomenon of flow is lacking, since as previously mentioned, it does not seem to appear in our physical theories.[11] I see this as the primary challenge for those committed to objective phenomena of flow to overcome. That being said, there are two possible responses one can make to this challenge. The first provided by Norton (2010) suggests that the fact that the phenomenon of TF does not appear in our physical theories should simply not give us reason to dismiss this evidence out of hand. Whilst this is a weak argument in favour of objective TF, it points to various epistemic weights one can assign to how our experiences inform our understanding of objective phenomena. The second response is to say just because TF is not part of our current standard physical theories, this does not preclude it from being a part of the causal story of some *later* physical theory. Dowker (2014, 2020) and Dowker and Butterfield (2021) suggests that something resembling objective TF might be present in a proposal for a theory of Quantum Gravity known as Causal Set theory. This shows that, at least in principle, that flow might be expressed in terms of laws or play a role in causal stories such that there may be some objective grounding to our subjective experience of TF. The jury is still out on whether TF plays any formal role in our physical theories. While our experiences should not direct the trajectory of fundamental physics as such, there is a long history of reinterpreting our intimate experiences in the light of new physics.[12].

[11] Authors tend to justify this by focusing on General Relativity as the most relevant specific example of physical theory, since it explicitly suggests an ontology of spacetime which given the discussion in Chapter 2 seems to be difficult to square with an objective passage of time. This can be contrasted with the case of Quantum Mechanics, which is less clear.

[12] Here I am imagining one's experience of weight (or rather weightlessness) and how this is reinterpreted in the light the equivalence principle in General Relativity.

What are the Data?

In the literature on objective phenomena, much has been written on the relationship between between phenomena and the corresponding data. Phenomena are the salient, underlying events, whereas the data are the products of experimental measurements that we take intended to capture some features of the phenomena. Another way of framing the challenge posed by Falkenburg's second criteria is to say that one of the largest obstacles in understanding the phenomenon of TF is locating the data associated with the phenomena. What is the data corresponding to the phenomenon of flow?

One direction one can take with attempting to find data for the phenomena of flow is in the measuring device that we use to measure other temporal features, clocks. However, clocks, as they have standardly been understood, only seem to provide data regarding time intervals, and not time's flow. One might need to bite the bullet and say that there is more to time than duration measurements provided by clocks. Namely, that clocks do not reveal all of the features associated with the underlying phenomenon of time. The fact that the data acquired from clocks doesn't seem to capture the phenomenon of flow, shouldn't necessarily persuade us that a feature of the phenomena isn't present. After all, every time we take data from phenomena, we never capture all the features of said phenomena, and this may be another example of this. This is the case with colour, our subjective experience of colour is somehow richer than the physical picture of a range of frequencies of light. It could be the case that while clocks do not give us access to the data of the phenomenon of flow, clocks would still be subject to the phenomenon of flow.

The other straightforward direction, since TF is so intimately associated with experience, then one might look in to the brain to try and locate the relevant capacity that is tracking or detecting the objective phenomena of flow. The onset of akinetopsia (sometimes referred to as "motion blindness") possibly shows an example what it's like not to have access, or to no longer be tracking this data anymore. However the account presented in this thesis will complicate this notion of mere *tracking* or *detection* of the phenomena, as will be explored more in later chapters.

Massimi (2011) argues that the discussion of the relationship between data and phenomena can be broadened by taking into account a Kantian perspective with regards to the nature of phenomena. In her words, phenomena are not "ready-made" and as such we need require a more comprehensive account of 'the given' in our observations, which a Kantian perspective provides.[13] She suggests that the relationship between data and phenomena can be understood analogously to the relation between appearances and phenomena. This attitude by Massimi will be picked back up in the coming sections.

3.3.2 Subjective Flow

Where might TF lie in the Kantian system?[14] As previously mentioned, this system relies on an a priori framework to structure our appearances of the world. Interestingly, for the case of TF, this a priori intuition is comprised of spatio-*temporal* features. So it seems that Kant unambiguously grounds temporal structure in the intuition of our cognition. Given this what can we say about the structure of the appearances and how various features of temporal experiences of time fit into them? Put simply, Sample (2019) attributes Kant's distinction of appearance and phenomena of time to the A and B series respectively.[15]

Sample (2019) provides an analysis on how one should interpret notions of A and B series with respect to the appearances and phenomena distinction. She claims that Kant should be thought of as an A-theorist with regards to appearances, and a B-Theorist when it comes to phenomena. Sample stresses both the epistemological and

[13]As Massimi (2011) points out, the overwhelming disagreement between philosophers will be with the rest of the baggage of Kant's Transcendental Idealist philosophy and how it would fit into this account.

[14]Falkenburg (2011) describes how the 3 criteria for objective phenomena are consistent with Kant's conception of phenomena. However due to the unconventional case I am examining here, it is worth specifically examining how TF might fit within Kant's system.

[15]Note that this is an ahistorical re-contextualisation of Kant's system since the terminology of A and B series was only introduced in 1908 with McTaggart (1908).

metaphysical distinction between appearances and phenomena. Whereas the first distinction focuses on the role difference appearances and phenomena play in our knowledge, the latter describes the phenomena as "complex objects that include the appearances and their relations to a non-ideal causal order that grounds them." This is because, in the Kantian account we begin with the manifest image of a 'moving now' of appearance, and from this we derive notions of temporal magnitude and duration.[16]

It is worth stressing that under this system, as Sample (2019) mentions; "neither temporal passage [Ablauf] in the time series [Zeitreihe] of appearances nor temporal order [Zeitordnung] in the phenomena is more fundamental on Kant's view". So talk about TF as being some kind of illusion, some kind of secondary quality, or being "just in the head" sells it short in this context. Despite temporal features being a product of intuition, within our cognition the distinction of appearances and phenomena does not entail a difference in fundamentality.

This might seem to settle it then: the flow of time is an appearance, grounded in the ideal intuitions of the subject, not in things in themselves. However, this attitude famously commits to be radically anti-realist with regards to *all* spatio-temporal features. Surely the scientifically-inclined do not want to relegate those features as "merely mind dependent". Surely there are mind-independent facts of the matter associated with the spatio-temporal features of the world. And so here lies the problem. The downside is that the story that the subjective account of phenomena tells us is far removed from the standard scientific picture of the world, which was precisely the opposite place we wanted to end up in this whole exercise. Science tends to "work its way in" by reconstructing agents from from an external model of the world[17]. But the Kantian framework does precisely the opposite, starts from

[16]This is broadly the reverse of how B-theorists usually approach things in which the A-theoretic description is taken to arise from the B-theoretic. This is generally done by taking B-theoretic properties to be primary and indexing on those events we can arrive at a relativised set of A-theoretic properties.

[17]See Hartle (2005) for an influential attempt at reconstructing agents from the perspective of physics and R. Gruber (2008) for an analysis of Hartle's work with respect to the flow of time.

the appearances of subjects and "works its way out" so to speak. The point of the subjective account is to stress that we cannot imagine ourselves as purely neutral agents, passively receiving the world around us.[18] To the contrary, if cognitive science has taught us anything it is that we radically *construct* the way we see, interact with and represent the world.[19] Therefore, along with metaphysical inquiry, we of course need to continue empirical inquiry into the nature of said construction to fully account for phenomena.

So if we don't want to fully subscribe to the Kantian system but nevertheless think of phenomena in the subjective sense, then we might suppose that *some* temporal features are provided to us from the appearances (i.e. we have some capacity that tracks and represents the objective features) but not *all* temporal features are like this. The question we arrive back to, the question that we started with is attempting to ascertain on which side of this divide TF in fact lies.

3.4 Neutral Monism: The Best of Both Worlds

As discussed above, to properly articulate TF in terms of phenomena (whether objective or subjective) certain metaphysical commitments (whether realist or anti-realist) must be made.[20] This might motivate one to take a step back and ask, what kind of metaphysical system would be able to do justice to the phenomena of TF? On the one hand we have the Objective Flow side which privileges the physical and struggles to incorporate flow alongside our physical theories. While on the other we have the Subjective Flow, which privileges the mental phenomena but does not seem to be compatible with the standard scientific picture of the world. Several authors have note the parallels between this discussion and the accounts of dualism

[18]As Chalmers (2021) recently put it, we do not have access to the "Edenic properties" of the world.

[19]See Ismael (2021) for a recent discussion on how this is done with regards to space in the context of the potentially space-less fundamental structure of quantum gravity.

[20]This is similar in spirit to the discussion regarding the *explaining* of flow, where before preceding with the argument, one must take as a premise the (non)reality of TF.

and materialism in the philosophy of mind[21]. I want to suggest that there is a way of resolving the dialectical tension by adopting NM.

3.4.1 What is Neutral Monism?

Monism is the metaphysical position that there is fundamentally only one *kind* of thing, one kind of substance. This is in contrast with Dualism which says that the world is comprised of two, distinct kinds of things. The 'neutral' qualifier specifies the nature of this substance. While a Physicalist might be monist with regards to physical entities, and an Idealist might be monist with regards to the mental, a neutral monist instead says that that something the world is made of is something else. I take the neutral entities to be neither physical nor mental.[22] As Bertrand Russel, himself an influential proponent of NM says "both mind and matter are composed of a neutral-stuff which, in isolation, is nether mental nor materal"(Russell & Baldwin, 2022).

The choice of NM is motivated by a desire to provide a metaphysics that is rich enough to account for both the physical and phenomenological aspects of reality whilst also being continuous with our scientific enterprise (as we saw with its application to QBism). How NM does this is partly by collapsing the distinction between objective and subjective phenomena, since these distinctions become two aspects of the same underlying neutral phenomena, thought of as the underlying neutral phenomena producing various features, either objective or subjective, depending on the function that the neutral entity provides. However as we will see we should nevertheless be able to recover the *apparent* split between objective and subjective phenomena. This is done by first examining the way in which the term 'function' here I am referring to both physical and mental function, in the way that W. James (1904) characterises it. As he puts it "subjectivity and objectivity are functional attributes solely, realized only when the experience is 'taken,' i.e., talked-

[21]See Paul (2013) and Primas (2003, 2007) for examples
[22]See Stubenberg (2005) for a review of the various iterations of NM.

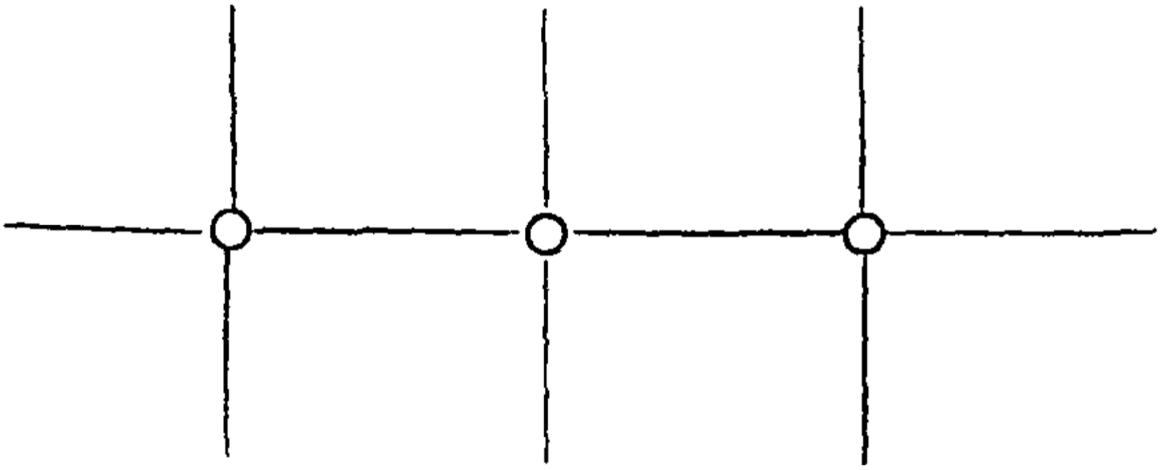

Figure 3.1: James schematic representation of pure experience.

of, twice, considered along with its two differing contexts respectively" (W. James, 1904). This dual aspect approach arises from what James's conception of "pure experience" when referring to Figure 3.1 he describes pure experience as

> ... either of two great associative systems, that of the experiencer's mental history, or that of the experienced facts of the world. Of both of these systems it forms part, and may be regarded, indeed, as one of their points of intersection. One might let a vertical line stand for the mental history; but the same object, O, appears also in the mental history of different persons, represented by the other vertical lines. It thus ceases to be the private property of one experience, and becomes, so to speak, a shared or public thing. We can track its outer history in this way, and represent it by the horizontal line. (It is also known representatively at other points of the vertical lines, or intuitively there again, so that the line of its outer history would have to be looped and wandering, but I make it straight for simplicity's sake.) In any case, however, it is the same stuff that figures in all the sets of lines.

A further distinction between various forms of monism is with regards to the mereological status of the neutral substance. The two states one could take are either a pluralist or priority monists which distinguish whether parts or the whole respectively should be considered ontologically prior. A pluralists would say that any objects are *built up* from the parts, while a priority monists would say that objects are *carved out of* the whole (normally conceived of as the entire cosmos). Schaffer (2010), Ismael and Schaffer (2020) and Calosi (2014) provide arguments for this priority monist view by appealing to entanglement, since, in general, one cannot completely specify the state of a system by simply specifying its individual parts separately, but instead one must treat it as a whole. The canonical example of this in the physics literature is the EPR experiment. A relevant revision to the standard articulation of priority NM that maybe well be necessary is given by Le Bihan (2018) in which he articulates a version of priority NM that is not fundamentally characterised in spatio-temporal terms. This is motivated by various results from a variety of theories of quantum gravity in which many of them strongly suggest that spacetime is somehow derivative from non-spatio-temporal stuff.[23] This also echoes the nature of neutral entities well, however it should not be taken a direct representation of them since ultimately the kinds of entities that make up the fundamental stuff of these theories, while not spatio-temporally individuated, the role that these theories play is to ultimately characterise (solely) physical entities. I will now go on to discuss further motivations for adopting priority NM which can be found from the study of quantum mechanics.

3.4.2 Neutral Monism in application

We see various applications of neutral monism in the work of Atmanspacher and Rickles (2022) in which, among other things, they track a variety of iterations of NM (what they referrer to as dual-aspect monism) by various mid 19^{th} and 20^{th} century scholars, notably a variety of physicists. What is particularly striking is that these various approaches developed in collaboration with physicists are almost always motivated by quantum mechanics. I will discuss the connections with

[23] It is difficult to make generalisations regarding the results from QG since there are a variety of different approaches. See Huggett and Wüthrich (2013) for a summary of various notions of spacetime emergence in current proposals of quantum gravity.

quantum mechanics, in particular a QBist approach to quantum mechanics that we encountered back in Chapter 2.

Participatory Realism

An contemporary example in which NM has been applied that builds on the work of John Wheeler in particular is in the interpretation of quantum mechanics referred to as Quantum Bayesianism, or more commonly, *QBism*. The first pass description of the spirit behind QBism is that, on the one hand, it is an epistemic account of quantum mechanics in which the formalism of quantum theory is understood to describe the ways in which an agents degrees of beliefs might change. However, on the other hand its not as if QBism has nothing to say regarding ontology. On the contrary, the ontology that has emerged from the study of QBism (inspired greatly by Wheeler) has been termed *participatory realism*.[24]

Regarding the necessity of the participatory elements that are thrust onto us by quantum mechanics, Rickles (2019) puts it as follows, " If we choose to read such results as the Bell and Kochen-Specker theorems, and even basic complementarity, as forbidding "essence preceding existence", then we must bite the bullet and accept some ineffability in the world as par for the course." This ineffability points us towards the stark epistemological limits that quantum theory poses on us but also the epistemological *necessity* of observers like us to generate the world. Lets now unpack the epistemological claims of QBism in more detail, which will then go on to motivate its corresponding participatory ontology. We can see the beginnings of the QBist sentiment in the following passage by Fuchs and Peres (2000);

> To begin, let us examine the role of experiment in science. An experiment is an active intervention into the course of Nature: We set up this or that experiment to see how Nature reacts. We have learned something new when we can distill from the accumulated data a compact descrip-

[24]For recent critical exegeses on participatory realism see French (2024), Fuchs (2017b), and Rickles (2019).

> tion of all that was seen and an indication of which further experiments will corroborate that description. This is what science is about. If, from such a description, we can further distill a model of a freestanding "reality" independent of our interventions, then so much the better. Classical physics is the ultimate example of such a model. However, there is no logical necessity for a realistic worldview to always be obtainable. *If the world is such that we can never identify a reality independent of our experimental activity, then we must be prepared for that, too.* (Fuchs & Peres, 2000, emphasis added)

The phrase *experimental activity* is then extended to any interaction an agent makes with the world. From this we can see more parallels with participatory realism and NM. Fuch's description aligns with Jame's description of the "intersecting lines" of mental occurrences with objects in Figure 3.1, only being realised and becoming publicly graspable at the points where they meet. A more formal version of this can be seen when we consider the Wigner's friend results[25] give further evidence to suggest that quantum mechanics does not permit one single objective picture of the world, independent of the characterisation by individual observers.

One complication is the application of Qbism and accounts like it to *priority* monism specifically. Dorato (2013) discusses this complication in the context RQM, however it and Qbism both share the same relevant features[26] that makes them both susceptible to this critique, namely "the quantum universe S can be known only by interacting with parts of it *from within*, namely by partitioning it into two parts, one of which, O must be *contained* in S" (Dorato, 2013). This puts pressure on the ontic priority of the whole rather than the parts contained and by extension, a global and consistent description of a block universe. I take it that while the mereological question of monism is open, one can hopefully already anticipate the resonances of a pluralist monism account with a broader perspectival account that

[25] See (Bong et al., 2020; Brukner, 2018) for a description of Wigner's friend experiments.
[26] For disucssion of such shared features see Chapter 2.

will be developed in the latter chapters of this thesis.

The takeaway, which I will apply to TF in the next section, is that both our ontology and epistemology point us in converging direction, emphasising the importance of agents, perspectives and subjective descriptions in the construction of our scientific story. That being said I don't want to imply that TF will necessarily have a distinctively quantum description. Rather that neutral monism takes this as a base metaphysical fact about the nature of reality and providing an explanatory grounding, participatory realism brings this up to the level of fundamental physical science and perspectival realism takes it further, applying it to our scientific theorising across the board. With these metaphysical and methodological lessons finally set, we can turn back to the problem of TF.

3.4.3 Neutral Monism Applied to Temporal Flow

Given this metaphysical setup, my suggestion is that NM is well poised to provide an account of phenomena, motivated by the case of TF. However, I do not want to give the impression that I will provide a comprehensive treatment of such an account here. My goal in this section is to gesture at how a particular combination of metaphysics and epistemology may provide a promising direction of inquiry which will be developed into a specific positive account in the coming chapters of this thesis.

We can see concrete examples of standard temporal features that are incorporated into our physical theories have correlations across this subjective/objective divide. This distinction tracks across the manifest/scientific image distinction introduced in Chapter 1 such as duration, direction and a privileged present have geometric representations that encode the relevant physical functions that correlate with the relevant subjective function. Other paradigm examples would correspond to one provided in Table 3.1 the top-left hand cell.

We can now see that with this approach the vicious slipperiness of TF may be articulated as a dual aspect phenomenon. One the one hand TF can be characterised as an example of (at least) a subjective function of a neutral phenomena. However, as mentioned in Section 3.3.1, unlike standard temporal features such as duration, and direction, it is not clear what the physical correlates of subjective flow to be found in our physical theories are. Hence, one question that arises to address this problems is how might we gain epistemic access to the relevant physical functions of the neutral phenomena that correlate with the subjective function? My suggestive answer to this come in two steps, the first is an interpretation of the products of scientific enquiry stemming from epistemic structural realism (ESR), and stemming from this the second step addresses the difficulty of gaining understanding of entities as yet outside the range of experimental regimes.

Massimi (2010) argues that a key takeaway of ESR, contra to its central goal as a theory of reference, instead it points to the proper kind of *epistemic conditions* that allow for reliable assertions regarding physical entities. Whereas the standard accounts of ESR dictates the kind of knowledge of (fundamental) objects we have access to, namely structural knowledge. Massimi's alternate conception is a less committal. She claims that the lesson we should draw from ESR is not that science produces structural knowledge that refers to features of particular objects, rather that the kinds of reliable statements we make of physical states of affairs have a particular form, and the form doesn't reflects a particular feature of the objects that it is referencing, but instead it reflects the kinds of epistemic conditions that produces them. So under this view of ESR, the kind of epistemic conditions that produce reliable statements regarding physical states of affairs are those that facilitate statements in mathematical, relational or broadly structural terms. This emphasis retains one of the attractive features of conventional ESR which is providing a response to the pessimistic meta-induction while sidestepping one of the major arguments against ESR, the notorious Newman argument.[27] In the context

[27]The argument originally articulated by Newman (1928) and re-articulated by Demopoulos and Friedman (1989) states that one of the central claims of ESR is that there is a given set of objects and a corresponding set of relations R that produce a structure W. However, as Newman (1928) points out, the former is not sufficient to uniquely specify the latter. This means that only the cardinally of objects with some set R in question in up for discovery. See also Ainsworth (2009) and Votsis (2003) for various defences of standard ESR from the Newman argument.

of NM this would correspond to providing reliable knowledge regarding the physical functions of neutral entities and fits with James' aforementioned idea of the physical attribute of neutral entities being context dependant. The relevant context for the physical sciences is now one that provides knowledge of structural form.[28]

Similarly to Massimi (2010), McKenzie (2021) interprets ESR not as an explicit theory of reference, but rather treats it as an epistemological stance. What chiefly characterises this stance is that idea that when doing naturalistic metaphysics we should foreground the fact that the language of physics is mathematics. Furthermore, that we should take seriously the role of physics in informing our fundamental metaphysics and that physics is first and foremost mathematical in nature captures the relevant structural features of our (objective) epistemic access to the world. Hence this aligns well with a fundamentally neutral monist metaphysics since this this tells us the *form* that the physical functions take.

With this interpretation of the products of scientific inquiry as a backdrop how then might we gain reliable knowledge of potential physical correlates of TF? This is made particularly difficult since many of the suggestions from the direction of QG regarding the physical correlates of TF are found in regimes that are well outside of current experimental capabilities. Despite this, there may still be hope for gaining understanding of these potential phenomena. Evans and Thébault (2020) discuss how we can gain can reliable knowledge from, as yet unmanipulable/inaccessible phenomena. Their central claim that elusive phenomena[29] can in fact, at least partially be understood by what they call 'inductive triangulation'. This triangulation is the process by which various sources of evidence may be brought to bear to gain understanding of a single phenomenon, this includes standard experimental practices, along with various theoretical considerations and the study of analogue models. As they put it, it is a process of "validation of the mode of inductive reasoning involved

[28]From this we can already see the beginnings of a perspective approach to scientific theorising that I will discuss in more detail in Chapter 5.

[29]In their paper Evans and Thébault (2020) focus on the infamous example of Hawking radiation for which we have yet to gain any empirical evidence for, but nevertheless have high credence for it's existence.

in the source-target inference via appeal to one or more distinct and independent modes of inductive reasoning" Evans and Thébault (2020, pg. 2). This allows for a much more creative approach in trying to gather reliable knowledge regarding physical phenomena compared to the standard data-phenomena relationship described in Section 3.2.1 and fits appropriately well with Massimi's interpretation of the products of scientific enquiry since it lends itself to a flexibility in methodology that a more strict realist account of the physical sciences might find objectionable.[30] This is the case since under Massimi's account of the physical sciences, what matters is providing reliable knowledge of physical states of affairs rather than playing some strict referential role. Therefore, what counts as evidence/data for a particular phenomena need not be restricted to direct detection.

The above approach to providing evidence for phenomena, with regards to our case of TF, leaves open to possibility for results from our study of phenomenology and neuroscience to be valid directions of triangulation in our understanding the potential physical functions of TF alongside other robust theoretical, philosophical considerations. Moreover, this allows for the potential for interplay between our understanding of the brain (or more generally agency) and fundamental physical sciences that will undoubtedly be needed to provide a full account of how the potential physical basis for TF brings about our phenomenology of TF. There have already been attempts to show on how a variety of results from the study of our experience of TF may constrain, inform, or even rule out physical theories that bear upon the potential physical basis of TF.[31] But the previous section on Praticipatory Realism at least gestures towards how these two seemingly disperate fields (phsyics and phenomenology) can be made to seem much closer connected that otherwise imagined. My discussion in Chapter 2 argued that it is not clear that approaches that attempt to capture TF within our fundamental physical theories have been

[30] Evans and Thébault (2020) mention this, referring to such stricter accounts as 'detectionist' forms of scientific realism.

[31] See R. P. Gruber et al. (2018) for an attempt at this, albeit in my opinion unsuccessful. See also Dowker (2014) for a discussion of how subjective experiences can be reinterpreted with different fundamental physical theories.

fruitful. Give this, it seems as though the more promising approach is to attempt to triangulate from another direction. The most obvious alternative direction is to see how the study of cognition and psychology is connected to our experience of TF and how such connections can shed light on the phenomenon. From this I will argue that we can more directly study the kind of subjective/objective correlations that one expects from a dual-aspect monist account.

So what kind of phenomena is flow? The complete answer to this question will depend in large part on the results of further empirical scientific inquiry. Specifically possibly on our study of the fundamental features of spacetime (or whatever entities spacetime is derived from) but probably more likely, our brains. Such a positive account of how our brains, and more generally our *embedded perspective*, as described using the framework of Predictive Processing brings about our experience of TF will be the topic of the remaining chapters of this thesis. This positive account dovetails naturally into a more comprehensive account of phenomena, namely Perspectival Phenomena. However this chapter argues, using the metaphysics and epistemology laid out in this last section for the potential of TF to be a dual aspect phenomena, one that collapses the fundamental distinction of objective and subjective phenomena in favour of describing the objective and subjective features of a fundamentally neutral phenomena.

3.5 Conclusion

This chapter characterises TF in terms of the two canonical kinds of phenomena that are found in the philosophical literature, as Objective phenomena characterised by Falkenburg (2011) and as Subjective phenomena as characterised by Kant. In the end each characterisation has its own advantages and challenges to overcome. It is still not clear how the objective phenomena approach can do justice in recovering our phenomenology, while the subjective phenomena approach struggles to find a place within the scientific image. However, tentative results in quantum gravity may provide an opportunity for it to do so. The subjective phenomena seem to be not congruent enough with the standard scientific metaphysics in ways that might be undesirable. I propose a resolution to this dialectic of standard approaches may be found in adopting a neutral monist metaphysics along with an epistemic structuralist stance with regards to the products of scientific enquiry. This approach has the potential of characterising flow as a dual aspect phenomena by collapsing the distinction of objective and subjective phenomena while doing justice to the products of the physical sciences and respecting the primacy of our epistemic conditions.

Chapter 4

Psychological Flow

4.1 Introduction

This chapter will build upon the conceptual groundwork of the previous chapter and begin to sketch how an account of TF can be instantiated within a particular framework from cognitive science. Very broadly, this chapter will argue that our experience of TF is a result of the ubiquitous updating of generative models by agents described under a Predictive Processing (PP) or Hierarchical Bayesian Inference (HBI) framework.[1] In Section 4.2 I'll begin by sketching our various desiderata regarding structural features of our experience of TF. In Section 4.3 I will describe the relevant features of the PP framework and propose what I term the Updating Hypothesis (UH). Finally, in Section 4.4 I will explore some implications of this account within the broader context of the philosophy of time and causation.

[1] A note on terminology: The terms Hierarchical Bayesian Inference is less common in the literature but describes the more general framework I am drawing upon. More common terms such as Predictive Processing, Predictive Coding and Active Inference are applications of HBI to specific domains. Given the more common usage I will sometimes default to use PP when setting things up, however in later section when the more general features of HBI become more relevant I will attempt to be more specific.

4.2 Desiderata of Temporal Flow

A good place to start before articulating the positive features of TF is with William James' slogan "A succession of feelings, in and of itself, is not a feeling of succession" W. James et al. (1890, pg. 625). A similar contemporary articulation is given by Dainton (2013) when he describes TF as "distinctively dynamic sensible appearances, sui generis forms of experience which are not reducible to (or composed of) sequences of static appearances." Something that these descriptions help illustrate is that what our experience as of TF picks out is something other than those that can be mapped onto standard spatial/geometrical models of time (in which concepts like succession and sequence can be modeled as a continuous line segment). I take it that it is in large part our experience of TF that explains the persistent resistance of some philosophers to say that time can be wholly modeled or represented geometrically and/or analogised with space. Our experience of time is said to have a distinct ingredient that space lacks. It would seem strange indeed to say that space *flows*. In short, there is something *extra* associated with our temporal experience other than mere succession that needs to be made sense of within the scientific image of the world before we can confidently say that we have done justice to said experience.

Various notions of temporality have a long history of being shown to be deep and possibly necessary aspects of our conscious experiences writ large, dating back from Kant (1908) to the phenomenologists of Husserl (2012) and Merleau-Ponty (1962). I won't be providing an exegesis of these authors, other than to say that despite such accounts arising from different intellectual traditions to that of modern naturalistic philosophy of science, I will be following the approach of Ramstead et al. (2022) who follows a 'naturalistic phenomenology' methodology, which is to say that it is possible to provide scientific models (mathematical or otherwise) that help understand features of lived experience. This is of course not necessarily solving the 'hard problem', but I take it to be aligned in spirit with the Sellarsian vision of bringing together the scientific and manifest images into a unified view of the world. One of the goals of this chapter will be to do justice to the purportedly ‘deep’ nature of our TF phenomenology within such a naturalistic framework.

Two other related features of TF that spell out it’s aforementioned deep nature and that will act as explanandums are its *ubiquity* and its *robustness*. The former states that our experience of TF extends not only across our various sensory modalities, but also beyond to a variety of other general cognitive experiences. While our experience of TF might be particularly vivid within our experiences of, say visual motion, we seem to also have experiences of TF that are associated with a wider variety of cognitive processes as eluded to by the aforementioned phenomenologists. As we will see in below this ubiquity across sensory and cognitive experiences has been a feature of TF that has been under-emphasised in the literature. The latter explanandum of robustness points to how it seems difficult *not* to have experiences as of TF. TF seems to be in tight accompaniment with many of experiences within a particular sensory modality or cognitive process. Though as we shall see in section 4.3.2 this tight accompaniment may be disentangled in some special circumstances.

Let me now say a few words on how accounting for our experience of TF is usually done within the B-theory. To do this, the main feature of the B-theory that one needs to know is, the ontology of time is just given by ordered pair relations of events. Think of a timeline with each pair of points on the timeline having a before-after relation. Given this, much of the focus within the philosophy of time literature has been to point out that nothing like the phenomenology of TF can be found within this picture, namely something over and above mere succession. Hence, the pull from the argument provided above. That being said, there are two main approaches to accounting of our experience of TF within B-theoretic metaphysics. The first, called Illusionism, grants that we have such an experience as of TF, however, since we live in a B-theoretic world this experience is some kind of mistake or illusion. The second kind of account, referred to as an Error Theoretic account denies that we even have such an experience as of TF. Instead, Error Theorists claim that we

	Perceptual	Agential/Self-representational
Illusionist	Paul (2013), Prosser (2012)	Young (2022)
Error Theorist	Hoerl (2014), Miller (2019b)	Ismael (2007b), Callender (2017)

Table 4.1: Various accounts of Temporal flow within a B-theoretic metaphysics.

have a mistaken *belief* that we have such an experience.[2] In this chapter I will be taking a tentative illusionist stance with respect to our experience of temporal flow, insomuch as I take for granted that we indeed have an experience *as of* TF despite a B-theoretic temporal metaphysics[3]. However, I hope to show by the end of this chapter that given the particular account provided here the term illusion is a misleading descriptor to capture the kind of phenomena of TF that is described in this chapter.

Another useful distinction that cuts across the Illusionist/Error Theory divide comes from considering the *source* of the Illusion or Error. Broadly those can either be Perceptual or Agential/Self-representational. In the Perceptual Illusionist our experience of TF is generated by features for our perceptual experience whose contents mistakenly represents objective temporal passage (as mentioned in Section 4.2). Similarly for the Perceptual Error Theorist, our ordinary perceptual experience of change and motion (along with ways of talking about our experience) generates a false belief of an experience of TF. The other source of Illusion/Error comes from agential experiences. Namely the distinctive experience of being the source of one's decisions/actions or some other feature of our self-representation. This can in principle be carved up as either Agential Illusionists or Agential Error Theorists. These distinctions, with examples from the literature are summarised in Table 4.1. As we will see in the preceding sections, one of the goals of the remaining chapters of this thesis is to provide an account that unifies across the perceptual and agential divide.[4]

[2]See Miller et al. (2020)

[3]The use of the terminology of 'experience *as of* TF' assumes that we have such experience of TF but signals that we are agnostic towards whether such experience is veridical or not.

[4]Note that this is slightly different to hot Bardon (2023) distinguishes these views. For example he characterises Young (2022) as more on the Error Theorist side. He does so because he interprets Young's (and many others) work in terms of *projection*. However using the standard distinctions

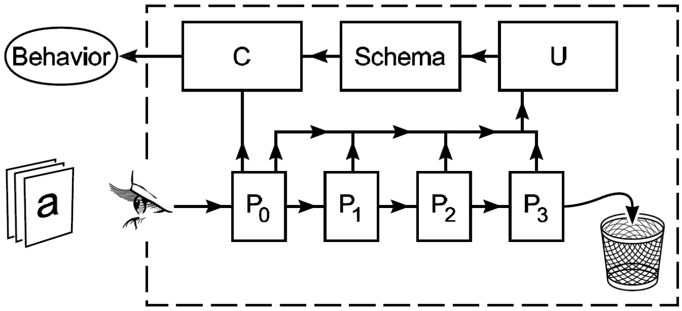

Figure 4.1: Hartle's (2005) schematic diagram of an Information Gathering and Utilising System (IGUS). Arrows represent information transfer between the various registers with $P_{0,1,2,3...}$ representing consecutive memory registers. C and U are meant to represent conscious and unconscious processing with a simplified model or schema of the external environment between them.

Let us once again return to a particular perceptual illusionist account for recovering our manifest temporal experiences within a scientific image was originally proposed by Hartle (2005) with what he refereed to as an Information Gathering and Utilising System (IGUS) which can be seen in Figure 4.1.[5] This account is one of the canonical approaches of the aforementioned strategy of thinking of an agent embedded in the spacetime manifold in an attempt to recover features of our temporal experience. This model for agents has been particularly useful in cashing out the general illusionist strategy for accounting for our experience of a privileged present by treating the apparently privileged present as an indexical. By leveraging the conceptual machinery of an entropy gradient from statistical mechanics, it is also able to account for the epistemic asymmetry of the past and future. However it has yet to fully account for TF since, remembering James' slogan, it would seem that such an agent would simply have a succession of experiences, rather than an experience of succession. Therefore, one way to think about the strategy employed in this chapter is to ask what kind of cognitive and perceptual architecture would be required for an IGUS-like agent to have an experience as of TF? We will discuss such an architecture now.

found in the literature, I take Young to be in a standard illusionist.

[5]It has received various alterations and improvements since its inception with Evans et al. (2021) as an excellent recent example.

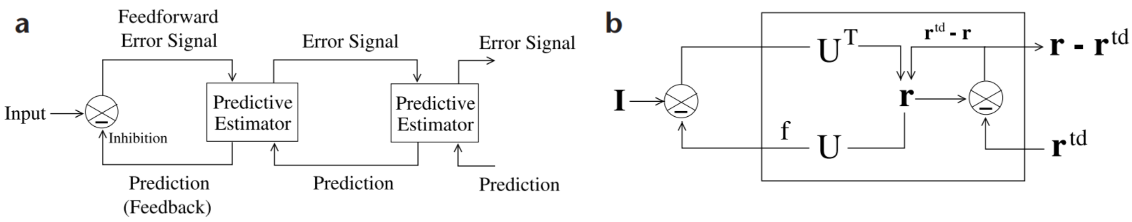

Figure 4.2: Schematic structure of Hierarchical Bayesian Inference. **(a)** The hierarchical structure **(b)** A schematic representation of an individual predictive estimator. (Rao & Ballard, 1999)

4.3 Temporal Flow from Predictive Processing

4.3.1 Brains as Prediction Machines

Predictive processing (PP) is an approach to cognitive science that emphasises top-down prediction and error minimisation as a canonical computation and overall unifying framework for understanding perception, cognition and action.[6] This is done through a framework of Hierarchical Bayesian Inference (HBI)[7] which is used to minimise the error across a hierarchy of generative models prediction of its inputs. A schematic representation of this process can be found in Figure 4.2.

Let us take a moment to distinguish some of the terms introduced above. Aitchison and Lengyel (2017) distinguish the core idea behind PP vs Bayesian Inference. On the one hand PP strictly says that "instead of representing the input directly, it is often preferable to represent the prediction error" (Aitchison & Lengyel, 2017), where the prediction error is just the difference between the input and the prediction signal. The motivation behind this is relatively straightforward and stems from the basic insight that underlies much of modern compression algorithms, which means that much of the information we receive has *structure*[8] which does not change, and so it is often much more efficient to only process the changes in the information being received. This is distinct from Bayesian inference which is simply the appli-

[6]See Clark (2013) & Gładziejewski (2016) for a philosophical treatments of the scope of PP in these areas.

[7]This framework is an application of an even more abstract process of Free Energy minimisation. For more on the Free Energy Principle see K. Friston et al. (2012), Parr et al. (2022)

[8]Another way of saying this is that one can characterize any string of information with an *entropy*, where an ordered string has low entropy and a random string has maximum entropy

cation of Bayes theorem 4.1 which combines prior probabilities of a hypothesis with the likelihood of the hypothesis given some input to produce posterior probability. Combining these two ideas gives the best of both worlds, the efficient calculation of predictions from Bayes theorem, with the efficient transmission of those predictions as prediction errors. The last step is to stack individual prediction estimators of the sort found in Figure 4.2 and we arrive at the general formulation of HBI. Dennett (2013) provides a useful framing of the hierarchical aspect of PP as 'expecting ourselves to expect', where top-down predictions attempt to predict the output of the lower-level estimators while the bottom-up error signals feed up the hierarchy updating the posterior of higher-level estimators.[9] As Clark (2013, pg. 183) puts it;"The beauty of the bidirectional hierarchical structure is that it allows the system to infer its own priors (the prior beliefs essential to the guessing routines) as it goes along. It does this by using its best current model – at one level – as the source of the priors for the level below, engaging in a process of "iterative estimation" [...] that allows priors and models to co-evolve across multiple linked layers of processing so as to account for the sensory data."

$$Posterior \propto Prior \times Likelihood \tag{4.1}$$

$$P(h|e) \propto P(h) \times P(e|h) \tag{4.2}$$

PP is not a mature scientific program, meaning that there are ongoing conceptual and methodological questions that remain unanswered.[10] Nevertheless it has already received much attention from psychology, neuroscience and philosophy with a growing body of empirical evidence in support of it.[11] The central claim from PP that is relevant for us is that our experience is not generated from 'bottom

[9]Price (2023) recently draws of Dennett's work to connect PP to a more general neopragmatist approach within philosophy. This will align closely to the perspectival approach developed in the next chapter.

[10]See Colombo and Wright (2017) for an discussion of how PP can be part of an pluralistic approach to explanation in cognitive science.

[11]See Walsh et al. (2020) and Ficco et al. (2021) for reviews of empirical work on PP.

up' sense data *per se*, rather our conscious experience is generated from 'top down' prediction provided by generative models. As Hohwy (2007) puts it "What we perceive is the brain's best hypothesis, as embodied in a high-level generative model, about the causes in the outer world." However, the role of perceptual input should not be under emphasised either. This point is well articulated by Orlandi and Lee (2019) when discussing the often-quoted description of our experiences within a PP framework as a 'controlled hallucination';

> Talk of "controlled hallucination", as well as the terminology of "error correction", suggests that the bottom-up signal only does the work of adjusting and fine-tuning the system's representation. Certainly, the bottom-up signal is indicating that the prior needs adjusting, and it is specifying the appropriate direction of adjustment. But even in a case where the prior is much more weighted than the bottom-up estimate, we are still just combining two separate estimates of the stimulus in a way that is essentially symmetrical between processing directions.

From the quote above we can see that an basic feature of this process is the adjustment or updating of prior model predictions, what is sometimes also referred to as the 'learning rate', given novel stimulus. This process is implemented across individual Predictive Estimators shown in Figure 4.2. This ubiquitous and basic feature of the PP story will be important for our later discussion of how TF is understood in various contexts.

However, while the previous quote focuses on perception as a key explanatory outcome of this framework, the general framework of HBI has also been applied to how we understand *action*. This has been appropriately named Active Inference[12] and is less of a distinct research program and more of a specific branch of the underlying unified framework provided by HBI.[13] This particular branch not only provides an

[12] See Seth (2013) and Seth et al. (2012) and Letheby and Gerrans (2017)

[13] Another way of cashing out the unity of these processes is by talking of so-called action-perception loops. This refers to the tight feedback that action and perception processing have within this more general HBI framework.

account for how action is to be understood and initiated within cognitive systems, but also provides us with a notion of the *self* as the result of a multilevel prediction of internal physiological processes[14] which will be particularly fruitful for our purposes. This will be elaborated on further in the next section.

As Hohwy et al. (2016) discusses, it is not simply a matter of minimizing prediction error, since on its own this does not require the *hierarchical* structure of HBI. What this hierarchical structure provides us is not just with prediction of expected error, but also a assignment of *unexpected prediction error*. It is the higher level Predictive estimators that gradually reduce the predicted probability of lower level hypotheses, eventually inducing them to change. This can be interpreted as a higher level prediction that the current state of the world will change, or in Hohwy et al. (2016) puts it, to what extent one 'distrusts the present'. A more formal schematic diagram of such a hierarchical structure can be found in Figure 4.3. '

4.3.2 Flow *qua* Updating

Walsh et al. (2020) summarises a key aspect of PP in the following way; "PP has at its core a process of "predicting the present, in which top-down flows attempt to match incoming sensory stimulations". They achieve this goal integrating information across the predictive hierarchy in which different levels processing information over various windows of time (Parr & Friston, 2017). This integration of a temporal duration shows how PP account for another of William James' insights, the 'specious present'. That is to say that our experience of the present is generated not from an instantaneous moment of time, but actually the result of an extended interval of time that is synthesised together.[15] This, alongside the "feeling of succession" mentioned in Section 3.3 brings us to how we might interpret our phenomenological experience of TF within a PP framework. To do so, let me introduce the central claim of this chapter which I refer to as the Updating Hypothesis (UH):

[14]See Apps and Tsakiris (2014) for an HBI account of self-recognition.

[15]What is sometimes refereed to as an Retentional model of time perception.

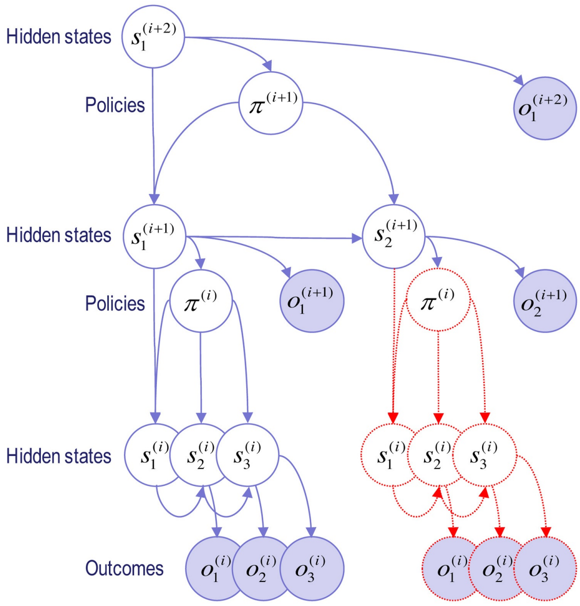

Figure 4.3: Bayesian Graph diagram from K. J. Friston et al. (2017) which illustrates the dependencies of so-called hidden states: s^i_τ, policies: π^i_τ (which combined represent each levels generative model) and outcomes: O^i_τ where the superscripts refers to the variables level in the hierarchy and subscripts refers to the time-step. We can see that higher level states influence a greater number of lower level states, generating "outcomes over nested timescales; like the second-hand of a clock that completes a cycle for every tick of the minute-hand that, in turn precesses more quickly than the hour hand. It is this particular construction that lends the generative model a deep temporal architecture. In other words, hidden states at higher levels contextualise transitions or trajectories of hidden states at lower levels; generating a deep dynamic narrative." (K. J. Friston et al., 2017)

> **Updating Hypothesis:** The content of our experience of Temporal Flow is the result of the *updating* across the hierarchy of generative models within a Predictive Processing framework.

Lets take stock of the problem before seeing how the UH can be used to address it. Remembering James' and Dainton's distinction between mere sequence or succession of experiences and our experience of TF. This was the core of the puzzle, since it seems as if the mere succession afforded to us from the B-theory was insufficient to make sense of our experience of TF. I argue that what the PP/HBI framework provides us with is a distinct higher order kind of change that is distinguished from the representation of 'first order' change of states of affairs in the world.[16] So an example of first-order change in this view would be a representation of a trajectory of an object through space, where a second order change is a change in which trajectory is being represented. A schematic diagram of this higher-order change can be found in Figure 4.4. Lets explicitly go through an example of visually representing a ball being thrown in the air. The 'first-order' change of the position of the ball is represented by a lower level hypothesis which would be something like "Ball if traveling in a parabolic arch, it will be at position x_1 at t_1, x_2 at t_2, x_3 at t_3, and so forth". But these hypothesise invariably update and change given changing stimuli and unexpected prediction error. This would result in a new hypothesis for the associated first-order changes of the ball (x'_1 at t_1, x'_2 at t_2, x'_3 at t_3). Importantly these hypotheses span across overlapping moments of time so that when there is the changing of hypothesis, this changes the representation of the very same moment in time (in the ball example this would means going from x_i at t_i to x'_i at t_i). This change in hypothesis provides distinct kind of change that is not of external states of affairs, but of the world-model hypotheses itself. Given this, we can see we have two distinct kinds of change simultaneously present, the lower level change represented by a particular hypothesis, and a higher-order change of the hypothesise

[16] Brief mentions of something resembling the UH hypothesis are mentioned by Hohwy (2020, 2022) and Hohwy et al. (2016), however the purpose of this work is to properly flesh out such an account and and locate it within a broader philosophical literature.

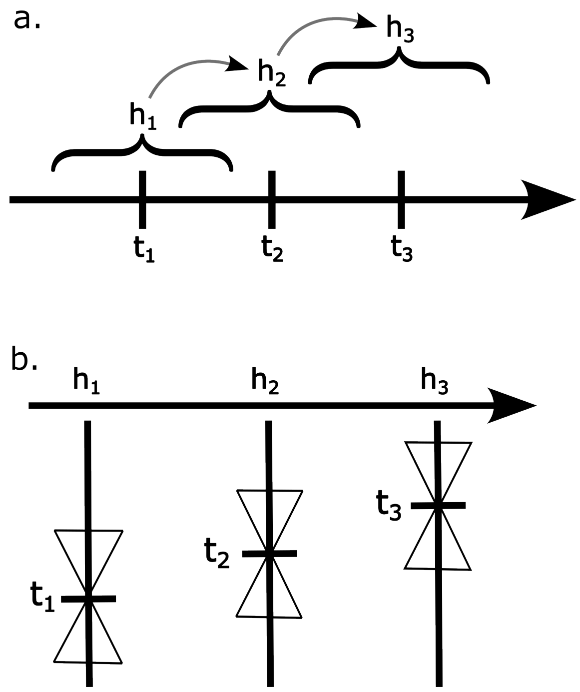

Figure 4.4: Schematic diagrams of the kind of 'higher order change suggested by the UH. **a)** h_1, h_2, h_3... are the various hypotheses that track/predict first order changes across t_1, t_2, t_3 (such as trajectories). The arrows between h_1, h_2, h_3 represent the updating of stable multi-level hypotheses and it is such changes that I am calling 'higher order' changes. Importantly there is overlap in the span of time that each hypothesis covers. **b)** Another way of representing the previous picture is by appealing to what in the philosophy of time literature is called *hypertime*. On the vertical axes are the perspectives of an agent at a particular moment t_i and the horizontal axes represents the changes in those perspective in virtue of the changes in hypotheses. This representation is equivalent to the one shown in **a)** due to the changes in h_i can ultimately be reduced to 'first order' changes across t_i.

themselves. Figure 5.3 demonstrates a single update of this kind and how it is a natural consequence of the need to predict trajectories. A schematic diagram of subsequent updating can be seen in Figure 4.4. This higher-order change is what the UH proposes to be the source of the variety of our experience of TF. Lets now see what this proposal can explain and illuminate for us.

One of the primary attractive features of the UH is that is situates the mechanism that generates our experience of TF in a suitably 'deep' part of our cognitive architecture. The process that the UH exploits (the updating of generative models) seems fit for purpose to show how an experience of dynamic temporality is baked into our conscious experience writ large. Lets now see how this hypothesis addresses the explanandums laid out in Section 4.2. Firstly, that our experience of TF is ubiquitously associated with our perceptual and broadly cognitive experiences. Since the process of updating of generative models across a given hierarchy is a ubiquitous process, we should expect, given the UH that our experience of TF should be similarly ubiquitous. While much of the discussion of what I refer to as TF has focused specifically on experiences of visual motion since they are particularly vivid, authors have also stressed that the dynamic temporal phenomenology is associated with auditory[17], proprioceptive, tactile[18] and olfactory experiences. Each of these modalities can be thought of as being driven by the updating of generative models within a HBI framework and hence under the UH we should expect an associated feeling of TF. Along with sensory perceptual experiences we can also take advantage of the aforementioned application of HBI to understand action, namely Active Inference. This can be seen as a unification of the aforementioned Perceptual Illusionists and Agential/Self-representational Illusionists as seen in Table 4.1. Under the UH, we have a single unifying process that generates our experience of TF associated with our perceptual experiences and our agential/self-representational experiences.

I take it to be a prediction of the UH that the more sophisticated the generative models within a particular perceptual or cognitive process are, the more intense, vivid or salient the associated experience of TF will be within that modality. Given this it is unsurprising that TF most often associated with visual motion is so vivid since it is a perceptual modality that uses a greater share of cognitive resources compared to our other senses.[19]

Alongside this, the UH explains why the experience of TF is so robust withing its various modalities. Given that updating of generative models is such a persistent feature of cognitive and perceptual processes, under the UH, we would expect the

[17] For a review of musical melody perception see Basiński et al. (2022) and a corresponding application of predictive processing see Schaefer (2014)

[18] See Geldard and Sherrick (1972) and Merz et al. (2019)

[19] See Hutmacher (2019) for a critical evaluation in which they cast doubt on this claim given that that vision is simply studied more often in part due to structural/cultural factors. However for our purposes it is sufficient to claim that visual processing takes a significant amount of processing, even if that processing is integrated across modalities.

associated experiences of TF to be similarly persistent. This persistence is seen throughout the various updating rates of predictive estimators throughout the hierarchy, as lower level estimators would update at faster timescales as higher level ones (Hogendoorn & Burkitt, 2019; Hohwy, 2012; Kiebel et al., 2008). Following James, our experience of TF across our specious present would be the integration of the various updating of higher and lower level predictive estimators across various timescales. Given this I will use the terminology of updating of 'a multi-level hypothesis' to refer to not just the updating of a single predictive estimator hypothesis, but of the integration of various high and low level predictive estimators hypothesis.

Wiese (2017) discusses how PP relates to our temporal phenomenology of *continuity* which while closely related to TF I argue is distinct. Continuity is the result of the various representations within the HBI structure *overlapping* and it is the integration of these overlapping representations that creates generates our experience of continuity. Using the notation from Wiese (2017)[20], $\hat{p}^{i}_{[a,b]}$ stands for a perceptual representation at the i'th hierarchical level over the time interval [a,b]. Given this we can construct a matrix which describes the most basic two-level hierarchical representation of a given event in which the top level predictive estimator spans across the time span of the two lower level predictive estimators:

$$\begin{pmatrix} & \hat{p}^{(2)}_{[t_{-2},t_2]} & \\ \hat{p}^{(1)}_{[t_{-1},t_0]} & & \hat{p}^{(1)}_{[t_0,t_1]} \end{pmatrix} \tag{4.3}$$

Wiese (2017) uses the above formalism to explain how this can help us understand the temporal phenomenology of continuity with the example of music:

> Here, the entire matrix represents, say, a succession of notes, but $\hat{p}^{(1)}_{[t_{-1},t_0]}$ & $\hat{p}^{(2)}_{[t_{-2},t_2]}$ jointly constitute a single representation of a note (the first note in the succession), and $\hat{p}^{(1)}_{[t_0,t_1]}$ & $\hat{p}^{(2)}_{[t_{-2},t_2]}$ likewise (the second note in the succession). On the one hand, the first note is represented as occur-

[20] Which is adapted from Grush (2008)

> ring before the second, because $\hat{p}^{(1)}_{[t_{-1},t_0]}$ and $\hat{p}^{(1)}_{[t_0,t_1]}$ represent properties (say, pitch) as being instantiated during distinct intervals ($[t_{-1}, t_0]$ and $[t_0, t_1]$, respectively). It is not true, however, that the first note is represented as occurring completely before the second, because the other property associated with the notes (say, timbre), which is represented by $\hat{p}^{(2)}_{[t_{-2},t_2]}$, is represented as being instantiated during a longer interval. Hence, the notes are represented as being distinct, but overlapping (where the overlapping part is not just a further note). This is why the entire representation is not just a representation of two events, or of a succession of events, but of a continuous succession.

This approach is similar in spirit with Le Poidevin (2007) who argues that "what gives rise to the experience of pure succession [...] is the conjunction of the perception of E with the very recent memory of C." (Le Poidevin, 2007, pg. 89) Where when Le Poidevin says 'pure succession' I take to be continuity. The distinctive difference I am drawing upon here is the difference between the *smooth integration* of our perceptual experiences, and the updating of lower level representations with repect to high level ones. I argue that the continuity described by Wiese (2017) and Le Poidevin (2007) is not only conceptually distinct but arises from distinct mechanism within the HBI framework.

The third attractive feature of the UH is that it does not require postulating extra fundamental metaphysical entities (which is the usual A-theoretic strategy) to provide some mechanism that brings about our experience of TF. This allows the UH to integrate itself within a broadly naturalistic 'scientific image' of time which is usually taken to be rest atop a B-theoretic temporal ontology. As I will discuss in Section 4.3, this helps explains why the experience of TF is so elusive. Unlike other temporal features such as duration and simultaneity, it seems impossible to assign TF to more basic physical processes such as a single particle in motion. This is because under the UH, TF is a byproduct of a relation between a particular kind of agent and that agents environment. It is not surprising then that it can't be naively 'read off' our basic equations of physics since (for the most part) it is not directly concerned with describing such a agent+world relation, rather it is usually cashed out as a system+environment relation. This point will be expanded upon in Section 4.4.2.

With the UH in mind we can more clearly examine why the IGUS that I discussed in Chapter 2 would not have an experience of TF. Looking at Figure 4.1, the first register P_0 leads directly to the conscious processing register (C). A very blunt implementation of PP within this IGUS would be to have the P_0 register not directly feed into C, but rather feed into the schema register that implements a HBI computation on that incoming sensory information. Only then is the result of that computation finally fed into the conscious processing register. More generally, if we implemented such an IGUS with a broader PP cognitive architecture then there would in effect be a re-wiring of the connections seen within this standard IGUS diagram. This provides the classical IGUS with a new capacity of sorts that it didn't have before. The capacity to track not just change simpliciter, but rather *change with respect to its own model of the world*. Let is now go through a couple more concrete examples that help us understand the application of the UH and how it can illustrate this new capacity. This analysis of implementing the UH within and IGUS shows how although the underlying temporal metaphysics has before-after relations (succession), by exploiting this agent+world relation we can extract qualitatively new phenomena.

This approach is an extension of work done by Callender (2017) who also makes use of the IGUS to account for our experience of the flow of time. Callender's proposal is that our experience of TF arises merely from the notion of the enduring *self* which flips back and forth between two schema for representing itself through time.[21] The account laid out in this thesis is perfectly consistent with Callender view, however it requires further structure with respect to the unified way in which a particular notion of the self (one born out of PP and Active inference such as the one by

[21] These schemas can be loosely thought of as those described by the A and B theory.

Apps and Tsakiris (2014) and Seth (2013)) is unified with how we process sensory stimuli.[22] The distinctively crucial point of this view is not just taking advantage of the notion of a backwards-looking autobiographical/episodic memory but also a forward-looking generation of multi-level prediction (what in the Husserlian language you would call retention *and* protention). It is particularly this stack of forward-looking predictions that the HBI framework provides that allows for the accounting of the specific phenomenology of TF rather than just a more general conception of an enduring self. The following case will help illustrate this.

Akinetopsia, otherwise known as 'motion blindness' is a rare neurological condition brought about by a lesion in the V5 or MT region of the brain in which patients report no longer being able to directly experience the motion of objects. Rather, they report seeing objects 'frozen' at different locations and different times, but with no associated motion phenomenology. This effect can also be induced (reversibly) in otherwise healthy subjects using transcranial magnetic stimulation (Beckers & Hömberg, 1992). Under the PP story, Akinetopsia can be seen as disruption of the updating of the relevant generative model predictions that provide us with the experience of visual motion.[23] This is further corroborated due to there being several feedback mechanisms known in the visual cortex such as V5/MT being responsible for generating predictions which are then sent to V1 (Beckers & Hömberg, 1992; Muckli et al., 2013). Importantly, what seems to be interrupted is the subjects experience of TF associated with visual motion specifically and not that their experience of TF *across the board*. This point is made very nicely by McKenna (2021) where they discuss Akinetopsia and the distinction between our experience of visual motion and temporal phenomenology more generally; "The key insight about these cases regarding subjective time, however, is that *subjective time itself does not freeze* in the same way as the particular moving objects in the visual field do. Rather, the subject is able to say that the object has remained stuck for some length of time.

[22] This approach will be discussed furhter in Chapter 6.

[23] For a detailed analysis of how HBI and PP are used in the neuroscience of vision see T. S. Lee and Mumford (2003).

The absence of visual motion no more affects the subject's overall sense of time than the absence of colour vision." (McKenna, 2021) In some sense it is a concrete illustration within the modality of visual perception of James' distinction, in which the subject has a succession of experiences (they can still make accurate judgements regarding the duration of events and even *infer* motion from the change in locations of objects at different times) but they do not have an experience *of* succession within the particular modality. Along with these differences in reported experience, the difficulty that these subjects have with interacting with the world shows that this difference in phenomenology makes a real and material difference with how these subjects engage with their environment. This shows that the experience of TF is not just a superfluous epiphenomena, but in fact supplies useful information to agents like us.

Another vivid example of how this account allows for experiences of TF that are independent of change in perceptual input is given by Hohwy et al. (2016) when they describe so-called Binocular Rivalry experiments. Very briefly, this describes a class of experiments in which different stimuli is given to each eye simultaneously. The distinctive prediction of PP that is born out in this experiment is that the subject reports seeing one image, *and then the other* despite (as was just mentioned) the sensory input is constant and presented simultaneously. This is explained in a PP processing framework by the variable 'learning rate' (or what I have just been calling updating) of generative models (Hohwy et al., 2016). Hohwy (2022) summarises the lesson from these experiments (with a similar though distinct notion of 'flow') with the following; "the flow of conscious experience is driven, not by the world, but by how self-evidencing engages with our beliefs about the state transitions of the world; conscious flow is therefore surprisingly detached from the current sensory input." I take this last sentence to get at the core of one of the idea presented in this thesis, that our experience of TF is not a result of us "perceiving flow" but rather we *construct* flow from the combination of sensory inputs and our cognitive architecture. This point will be expanded upon in Chapter 5.

4.4 Zooming out.

In this final section I will foreshadow and begin to connect the ways in which the ideas presented so far will be expanded upon in the final chapters of this thesis. Namely where the account I've presented fits into the standard views within the philosophy of time and how it begins to point us towards a perspectival account of TF.

4.4.1 Rethinking Illusionism

I'll begin by discussing how the term 'illusionism' is an misnomer for the account of TF described in this thesis. As mentioned in section 4.2 the account of illusionism hinges on a whether our experience of TF is veridical or not. Veridicality is usually taken to mean whether an experience represents some element of mind-independent reality. The thought goes, that since our world is taken to have B-theoretic temporal metaphysics, it follows that TF is not a part of mind independent reality which implies that our *experience* as of TF represents something that is not an element of mind-independent reality, therefore it is not veridical, and hence it is an illusion. A characterization that comes closer to the one articulated in this thesis comes from Farr (2020b) in which he distinguishes illusionism and reductionism[24] with respect to our experience of TF, where in both cases we have an experience of TF in a B-theory metaphysics, however the reductionist contends that our experience of TF does not represent mind-independent TF (namely, A-theoretic temporal passage). As I have suggested throughout this chapter, our experience of TF represents the higher order change of our world-model. The experience of TF is a product of the *combination* of mind-generated prediction and sense data. So while is not representing mind-independent elements of our ontology *tout court*, external sense-data is nevertheless a necessary component to generate the experience. It is not only sensitive to external stimuli but robustly represents a feature of the agent-world interaction, namely that

[24]Otherwise known as a deflationary view, this is closely related to the Error Theory of passage by Hoerl and McCormack (2019).

of the higher order change which is the change in an agent's world model. SO the view presented here states that while our experience of TF is mysterious at first, and might sometimes motivate us to theorise about radical metaphysics to account for it, it nevertheless is ultimately reducible to straightforward change.[25]

This distinction away from illusionism helps sidestep one of the challenges that illusionism faces, the intelligibility problem.[26] Under the view presented above, given that it does not represent some systematically false states of affairs, then there is no explanatory burden to bear regarding how one can come to represent such states of affairs if one never actually encounters them. However, as I will hope to show in the subsequent chapters, the content of our experience of TF can indeed help account for it *seeming* like it represents rhobust temporal passage.

Let's now connect this account to the standard metaphysical notions used in the philosophy of time. This account aims to locate our experience of TF within a B-theoretic metaphysics as described in Section 4.2. That is to say within a metaphysics where TF is not a fundamental feature. Standard accounts of this kind are often referred to as "weak passage" or "anemic passage" (Skow, 2015) since it purportedly (among other things) does not do proper justice to the phenomenology.[27] However, I hope to have shown that my account does do justice to the phenomenology in a more satisfying way than previous accounts of TF. As mentioned in Section 4.3.2 the PP account of TF unifies and cuts across the perceptual and agential/self-representational accounts of TF as the source of the experience is from a canonical cognitive process that spans across perceptual and cognitive processes.

4.4.2 Perspectival Change

What is our experience of TF representing? As I have suggested throughout this chapter I argue that it represents the change in the multilevel hypothesise of our

[25]What is sometimes called in the philosophy of time as 'at-at' change. (ie, the particle is here *at* t_1 and there *at* t_2.). This point will be discussed further in Section 5.3.3.

[26]See Chapter 1 section 1.3.6 for a discussion of the intelligibility problem.

[27]Refer back to Chapter 1 for a discussion of anemic passage.

world-model within a PP/HBI framework. Not change simpliciter, such as might be modeled with the changing content of memory registers appearing at different points along an IGUS's worldline, or within the PP framework, the change represented by a single multi-level hypothesis. But instead, the change in our *expectation* of such changes. I think this can be thought of more evocatively as a kind of perspectival change. In other words, our experience of TF represents *change with respect to a particular agential perspective*. This is precisely the new representation capacity mentioned in Section 4.3 that the new and improved IGUS possesses which the original one that Hartle (2005) proposed does not. Namely, the ability to track the change of the internal model of the world that it has.

Kirchhoff (2018) touches on the perspectival nature of PP when he discusses what he calls the *ecological–enactive* interpretation of PP which teases out the distinction between perceiving and imagining under a PP framework:

> "perception is depicted as constrained - in a way that imagination is likely not to be - by an organism's embodiment and the environmental context."

Under this view, while perceiving and imagining are unified under one underlying process, namely HBI, however they are different manifestations of it, born out of different conditions. A consequence of the view sketched out in this chapter that both the experiences of perceiving and imagining would result in associated experiences of TF given that they would similarly go though the process of updating of generative models.

The perceiving/imagining mirrors the veridical/non-veridical distinction insomuch as the former attempts to reliably track features of the external environment while the latter does not. However the PP approach shows how such a clear cut distinction is less useful under this view. Namely that our experiences are simultaneously *generated* and *constrained* in a way that cannot be cleanly untangled.

This account fits well with the influential dual systems approach of temporal cognition proposed by Hoerl and McCormack (2019). These dual systems refer to a temporal updating system and a temporal reasoning system. A natural question to ask is which of these dual systems does this account of TF fit. I take it to very naturally fit within the temporal updating system. Hoerl and McCormack (2019) say that "crucial to the temporal updating system is that it deals with changing input by *changing representations*, rather than by *representing change*." This distinction points to the 'higher order' aspect of TF I have attempted to spell out. While individual multilevel hypothesise represent change, the UH states that our experience of TF is a result of such changing hypothesise, or changing representations. Hoerl and McCormack also argue that the temporal updating system is phylogenetically and ontogenetically more primitive, which aligns with the claims by Pezzulo et al. (2022) that given this Bayesian updating is a purportedly ubiquitous feature in the PP story, that it would be a more evolutionary basic feature of our cognition compared to more abstract temporal reasoning such as mental time travel.

4.4.3 Analogy with Causation

Let me finish by emphasising the points made above by describing what I take to be an analogous situation to TF, that of causation. Causation, it is often said is nowhere to be found as a fundamental concept within our physical theories[28]. Instead, contemporary accounts of causation (there are many) require the addition of some notion of agency or intervention for a robust notion of causation to be fully fleshed out. As we will discuss at length in the upcoming chapters, it is treated as *perspectival*.[29] Now just because a notion of causation cannot be directly 'read off' out fundamental physical theories, and just because we have to introduce notions of agency to account for it, does not mean that it is a mere mental projection or

[28]Most famously put by Russell (1912), "The law of causality, I believe, like much that passes muster among philosophers, is a relic of a bygone age, surviving, like the monarchy, only because it is erroneously supposed to do no harm."

[29]This approach to causation in contemporary philosophical discussions is heavily influenced by the interventionist account laid out by J. Woodward (2005). For other examples of perspectival treatments of causation, see Ismael (2007a), Price (2007, 2017), A. S. Fernandes (2017) & Evans et al. (2021)

illusion. On the contrary, both causation and TF are useful way that agents like us represent the world that *they* inhabit, which includes them! Causation then reflects both the external structure of observed dependencies of physical states of affairs *and* the capacities of situated agents such as ourselves to intervene on such states. Similarly, the phenomenology of TF is a result of a mixture of the kinds of sensory patterns that situated agents engage with on an everyday basis and the kinds of expectations and affordances that such situated agents have towards such patterns. Both TF and causation are neither wholly 'out there' in the world, independent of us, nor are they merely a projection that our minds are imprinting onto the world. They are a product of the combination of our agential perspective and physical states of affairs.

This sentiment is put very well by Ismael (2017) when she says, "Separating of 'the products of the processing' from the absolute structures on which that processing operates gives us an account of the phenomenology that neither reifies the features that turn out to be frame-dependent, nor dismisses them as illusory." Here 'the products of processing' can be thought of as the HBI structure of our cognitive architecture and the 'absolute structures' would be the B-theoretic or the underlying spacetime structure.

With all that being said, how to precisely spell out this mixture for the case of causation is still an ongoing topic of research and so it also is for TF. I leave it open that the analogy between causation and TF may have deeper connections that what I have eluded to. Specifically I have in mind is the connection between our experience of TF and how our brains model the causal structure of the world which is itself a large focus in the the PP literature, as Clark (2013) puts it;

> "Brains (...) are statistical sponges structured by individual learning and evolutionary inheritance so as to reflect and register relevant aspects of the causal structure of the world itself."

4.5 Conclusion

The goals of this chapter were twofold. The first was to sketch out an account of our experience of TF within the framework of predictive processing. Second is to discuss the consequences of such an account. This account argues that within a B-theoretic metaphysics, our experience of TF of can be thought of as the product of the ubiquitous updating of generative models by agents who's perception and cognition is described using a Hierarchical Bayesian inference framework. Using the standard model of agents used within philosophical attempts to recover our experience of time from a more fundamental basis, this approach results in a new capacity which allows such agents represent a kind of perspectival change. This notion of perspectival change shouldn't be thought of as illusory just because they necessarily include persepctival features. Provided a particular perspective, our experience of TF tracks something consequential and useful to us.

Chapter 5

Perspectival Flow

In this chapter, I will first flesh out a fuller account of *perspectival realism* which has, in one way or another, already been foreshadowed throughout the thesis so far. I will go on to show how this perspectivalist approach has been applied to the philosophy of time to help understand the apparent tensions between the scientific and manifest images of time. I will then go on to show how the ideas presented in the thesis so far can be placed in this perspectivalist framing to provide novel insight into the experience of TF. Notably, I will argue that TF can be thought of as a projection that is nevertheless veridical.

5.1 Perspectival Realism

There has been a growing and rich approach within the philosophy of science called "perspectival realism" that aims to offer a middle way between previous realist and anti-realist accounts regarding the products of scientific inquiry. This approach spans multiple research programs but has a common thread, which is an epistemological stance that emphasizes how our situatedness as agents necessarily influences the methodology and character of scientific knowledge. The sense of the term "perspective" is intentionally broad so as to capture the variety of ways in which notions of perspective influence our theorising, ranging from historical, cultural and social

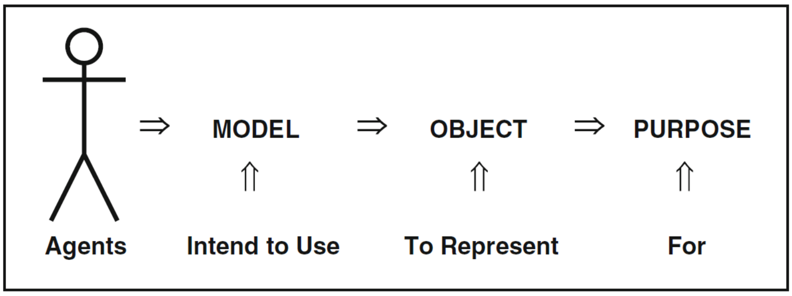

Figure 5.1: Schematic depiction of the account of models by Giere (2010).

influences, to inertial frames of reference, to the ways in which light bouncing off objects falls onto our retinas. The crucial point being that with each of those senses of perspective we have (among other things) an unavoidably *partial* access to the world, and it is only through precisely articulating the ways in which our particular situatedness influences this partiality can we provide an accurate account of our scientific theorising[1].

The broad strokes introduced here have been a part of philosophical discourse in a variety of forms[2] but an influential contemporary articulation comes from Giere (2010, 2019) in which he outlines an account of scientific models that expands the orthodox two-way representational relation between model and target system. Giere does this by articulating how the role of a particular agential perspective is embedded within this relation. As shown in Figure 5.1, "Agents (1) intend; (2) to use model, M; (3) to represent a part of the world, W; (4) for some purpose, P" (Giere, 2010).

This account of models highlights the fact that they are, as Weisberg (2012) puts it, "interpreted structures". Models cannot stand on their own, but necessarily require the *modeler* to spell out not only the structural mapping between model and target but the purpose of said mapping (ie, what mechanism or phenomenon are you trying

[1]One form of situatedness that I will *not* be focusing on is how the social/cultural/historical situatedness of science influences the values that guide (and hence the products of) scientific inquiry. This is not because this form of situatedness is unimportant, on the contrary, it is arguably the most impactful kind of situatedness that influences the scientific process in a variety of domains. This is reflected in the large literature on social epistemology that has emerged in recent decades attempting to articulate these influences (O'Connor et al., 2024). However, this thesis examines those kinds of situatedness that connect to issues within the philosophy of time, hence I will focus on those to the exclusion of other kinds.

[2]Kant is a chief example but could dump a few more examples.

to understand/predict/manipulate in the target). This interpretational aspect of models comes into play particularly when we try and asses the effectiveness of a particular model.[3] Take a miniature diorama of a train bridge, we might say that this is intended to model/represent a life-sized bridge somewhere out in the countryside. We might reasonably ask, 'is this a good model of the life-sized bridge?' If we intend to model the stressors on the beams of the bridge, then it is probably not a good model since the diorama materials are surely different and the square-cube law would make it such that the relative loads on various parts of the model would change when scaled up. However, if we were instead interested in modeling how the bridge would cast shadows on the surrounding environment, then it may well be a perfectly adequate model for that purpose.[4]

This point was previously summed up nicely by van Fraassen (2008, pg 80) in a discussion regarding models: "The activity of representation is successful only if the recipients are able to receive that information through their 'viewing' of the representation. But what are the conditions of possibility for this reception? The recipient must be in some pertinent sense able to relate him or herself, his or her current situation, to the representation." An persistent example van Fraassen uses to illustrate this is the common example of a map. On the one hand, while a map on its own may give the user some insight into the global structure of a landscape, on the other to actually *use* the map (and importantly for scientific models, to empirically validated it) one needs to *locate* the user on the map. This is analogous to various representations of General Relativity in which you can have a frame-independent representation or a frame-dependent one. Once formulated, the measure that is used within Special and General Relativity is the spacetime interval since it is the quantity that is not frame-relative, as opposed to mere distance or duration. However, for the theory to make contact with observations we need to index to a particular frame of reference with particular coordinate system of distances and duration. This shows that this process of indexation is necessary for any theory to make empirical

[3] Where the conditions for effectiveness are of course also relative to an agents goals.
[4] See Cartwright (1983) for an influential articulation of this point.

contact with the world. However, just because notions of distance and duration require this indexing does not mean that they are not real. Relativity is very clear on the predictions one would make on distance and duration measurements *given* a particular reference frame. Nevertheless, the point is that there are other representations, such as with the spacetime interval, that require less indexation or context-specific information. In other words, to use a map you first need to specify where you are *on that map*. This point articulated well by Ismael (2007a):

> It's worth emphasizing as a general point that a perspectivalist view of some concept is not eliminativist, or anti-realist. Compare the difference between perspectivalism and anti-realism, with regard to familial relations. 'Mother', 'grandfather' are perspectival. Their extensions depend on where the user is situated on her family tree, but there is nothing unreal about mothers, or grandfathers. It's a discovery that one makes when one crosses hemispheres that not only time zones, but also seasons, are perspectival. The most famous example of scientifically discovered perspectivalism is the treatment that Einstein gave spatial and temporal notions. In the Special and General Theories of Relativity, relations like 'happens at the same time as' and 'is 30 miles away from' turn out to be relations to inertial frames. If objectivity is measured by invariance under transformations of perspective, what happens when you attain a more objective level of description is that properties at the lower level are reconstructed as relations to parameters supplied by contingent features of situation. *To give a perspectivalist reconstruction of a concept is to transcend the features of our collective or individual situation that would otherwise constrain its translatability to a context in which those contingencies don't obtain.* (emphasis added)

A recent book by Massimi (2022) builds significantly on Giere's work and provides an account of Natural Kinds within a perspectival realist framework. Her analysis is thoroughly steeped in historical and contemporary scientific examples that provide case studies to illustrate the overall project. One of the central goals of the project is to provide an account of "natural kinds with a human face".[5] She defines these to be "(i) historically identified and open-ended groupings of modally robust phenomena, (ii) each displaying lawlike dependencies among relevant features, (iii) that enable truth-conductive conditionals supporting inferences over time." (Massimi, 2022, pg 226). In the next section we will see how this account of natural kinds can be understood within the account of TF articulated in this thesis.

In a similar spirit to the discussion of phenomena in Chapter 3, the ethos of contemporary perspectival realism found in contemporary 'naturalistic' philosophy of science has recognisable echoes in continental/phenomenological traditions of philosophy. Berghofer (2020) articulates these similarities with the help of Husserl. One of the key differences (among many) with the two traditions is that of *methodology*.[6] Returning to our aforementioned example of Giere (2019) who stands squarely within the contemporary analytic tradition of philosophy of science, justifies his approach by appeal to empirical sciences. In contrast with Husserl and other phenomenologist of the time who arrive at similar conclusions regarding the perspectival nature of perception (among other mental states) through introspective practices. I take this inter-methodological agreement to reflect a kind of triangulation of evidence[7] in favour of the general approach of perspectivalism. Similarly, as in Chapter 3, the metaphysics of Neutral Monism supports the idea that even *in principle* there is no 'view from nowhere' or 'third person perspective' of nature. This just reinforces what might have been thought of as a contingent limitation of the scientific process and reiterates the *necessity* of the perspectival nature of the products of scientific inquiry. Lets now examine this claim by way of example.

This approach to models and representation more generally also helps address objections in Chapter 3 regarding epistemic structural realism (ESR). As a reminder,

[5]See Hacking (1996), who Massimi credits at length, for a more specific articulation of so-called 'human kinds' in the context of psychology and the social sciences.

[6]For a characterisation of the differences in continental and analytic philosophy in terms of methodology see Levy (2003)

[7]Similar to the inductive triangulation described in Chapter 3

ESR is a thesis regarding the form of knowledge that the physical sciences can provide, namely structural/functional knowledge as opposed to knowledge of intrinsic qualities or entities. This was then proposed as a way to characterise the form of knowledge gained by the objective/physical aspect of dual aspect phenomena. However, an important objection to this view originally proposed by Newman towards Russell's account of structuralism[8] is that if all we can know is the 2-way structural mapping between theory and world then this leads to a radical kind of indeterminacy regarding our scientific knowledge, limiting it to only being able to discover the cardinality of such a mapping.[9]. Hence there is no way for the mathematics 'on their own' to pick out a specific privileged structural mapping over and above any other. Given this, the only shared feature that all of these structures share is their cardinality and hence this is the only feature that we can justifiably say to have discovered. The solution to this problem, given what we have outlined above, is at its core relatively simple, scientific inquiry does not merely produce a 2-way relation between theory and world, but (at least) a 3-way relation between theory-agent-world. This provides room and a justification to privilege certain kinds of mappings depending on the interests of the agent in question.[10] What is attractive about this approach is that we can maintain the core claim of structuralism regarding the nature of scientific knowledge while connecting the view to a more methodologically situated epistemology.[11] One might respond that this is undesirably anti-realist, or at the very least, overly contingent on our interests. However, as the perspectival realists remind us, there can be a robust notion of objectivity that can be salvaged

[8]As van Fraassen (2008) points out however Newman's objection can be applied to other structuralist accounts in the history of philosophy.

[9]Briefly, this is because "Suppose that the world consists of a set of objects whose structure is W with respect to some relation R, about which nothing else is known. Any collection of things can be regarded as having structure W provided there is the right number of them."(Ladyman, 2023). See also Ainsworth (2009) and Votsis (2003) for various defences of standard ESR from the Newman argument.

[10]van Fraassen (2008) discusses this reply to the Newman problem for structuralism and calls this approach *empiricist structuralism*. As he says " "there is nothing useful to be found in 2-place structure-phenomenon relations alone when we try to understand representation. Anything we see by way of such relations is something abstracted from the 3-place relation of use of something by someone to represent something as thus or so."(van Fraassen, 2008, pg. 258)

[11]Massimi (2010) makes this claim by arguing that the lesson of ESR concerns the proper *conditions of possibility* of scientific knowledge.

from this view despite its dependence on observers (Evans, 2020).

The analysis of causation has been a topic that has been particularly fruitful within the perspectival realism literature[12]. This is notable since a perspectivalist approach to addressing the philosophical puzzles surrounding our temporal phenomenology is analogous to that of causation since one of the key puzzles that a perspectivalist approach to understanding causation sees itself poised to solve is why it seems that despite notions of causation not being readily apparent in our fundamental physical theories[13] it is apparently a necessary concept in both everyday life and in scientific contexts. The apparent lack of causation in our fundamental physical theories stems primarily from the fact that for the most part the physical laws are time-symmetric[14]. From this, the interventionist account of causation is developed, in conjunction with the application of the formal machinery of statistical mechanics.

5.2 Tensed time as perspectival

Lets now move on to how this general perspectival approach can be applied to our understanding of time. Staying within a B-theory ontology, a now common B-theorist strategy has been to argue that all tensed talk is essentially perspectival. "As an element of a linguistic representation, [tense] is typically understood as what is responsible for the encoding of perspectival information, or more precisely the perspectival way the information about the temporal dimension is conveyed." (Torrengo, 2018). In short, talk of "now" is analogous to talk of "here", both being indexical statements picking out the location (spatial or temporal) the locution is uttered. A recent example of a perspectival realist account of the privileged present is found in Slavov (2020). Such accounts attempt to explain why such tensed talk

[12]For examples see Price (2007), Ismael (2016b), J. Woodward (2007), Evans et al. (2021), Loewer (2020), Papineau (2022)

[13]This is on top of the fact that time and causation may indeed have a shared explanatory story. Here I have in mind particularly how our brains model causal structure may be intimately linked to how it models temporal structure.

[14]For a canonical discussion of time-reversal see Albert (2000) and Earman (2002). For a more recent discussion see Roberts (2021)

seems indispensable to us, despite not being an observer-independent feature of the world. One of the main domains within naturalistic philosophy in understanding the perspectival nature of time is accounting for its direction, otherwise known as the 'arrow of time'. The key concept used to account for the various arrow of time is treating it as an emergent phenomena rather than a fundamental one.[15]

We can say more about how we are to understand the role of agents play in how we are to understand how time is constituted. One such question is regarding how to distinguish temporal and spacial dimensions given their similarities in spacetime models in which they are to be treated as parts of a unified whole. A response in line with the perspectival approach has been articulated by Callender (2017) and further developed more recently by Baron and Evans (2021) in their formulation of *temporal perspectivalism*. They claim that "t is a temporal direction for an agent a iff t is the direction along which the most useful determinations can be made, from a's perspective" (Baron & Evans, 2021). This places agential perspective and the corresponding interest for informative laws right at the heart of the *definition* of what counts as a temporal dimension.[16] We can see that not only is a notion of perspective a way of indexing on our spatiotemporal location, but *is the very means* by which we can provide informative explanations and predictions of phenomena. Tying this approach to the Massimi/van Fraassen terminology presented above, we can say that the means by which we model time requires a 3-way relation of model (say General Relativity or some more general notion of spacetime), agent (the fact that we are located within such a spacetime and have interests in informative laws[17]) and the target system (world). The overall goal of the thesis is to integrate our understanding of the phenomena of TF within such an account. As we will see

[15]Price (1996), Albert (2000), and Rovelli (2017) for examples of such approaches. While the singular term 'arrow' is often used, Price (1996) reminds us that there are in fact several arrows of time that need accounting for within physics, where some examples include the cosmological arrow, the radiative arrow, the statistical mechanical arrow and the casual arrow. For convenience I will stick to the singular term and attempt to disambiguate when relevant.

[16]See L. James (2022) for a discussion of how Baron and Evans (2021) and Callender (2017) work can be understood in the light of empiricist considerations.

[17]This is an application of the 'Best Systems' account of laws of nature from Lewis (1983) in which laws are taken to be mere descriptions of the world which manage to balance a range of epistemic virtues such as predictive power and simplicity.

the general feature of agents with interests in informative descriptions/predictions coupled with the particular cognitive architecture of HBI will be how TF enters the picture and is a natural extension of the view presented by Callender (2017).

5.3 Flow as a Perspectival Phenomenon

We now arrive at how TF can be understood within this broader perspectival approach. In this section I will discuss how TF fits into the taxonomy of Natural Kinds proposed by Massimi (2022) and connect the discussion of HBI to the more general treatment of time within the perspectival literature.

As mentioned in Section 5.1, Massimi (2022) develops a perspectival account of Natural Kinds. Massimi argues that they have served four distinct functions: The first is that of *Naturalness* which states that Natural Kinds ought to, following on from W. V. Quine (1969), pick out "'functionally relevant groupings in nature". The second function is *Unanimity* which says that "Natural Kinds are designed to identify features common to a class of entities." *Projectability* is the feature of natural kinds that they are conducive to inductive inferences.[18] The last function is *Nomological resilience*, which is related to projectability given that it says that "natural kinds are taken as supporting laws of nature".

However, Massimi is very careful to point out that the kinds we deal with within scientific contexts often challenge the way we make sense of how each of these functions are to apply to various instances of natural Kinds. Given this, Massimi further distinguishes natural kinds based on how they challenge these four functions.

- Engineered kinds: Kinds that are not found *in nature*, but instead those that we *create*.

This challenges our usual treatment of naturalness what contrasts it with contingently engineered kinds that serve particular contingent purposes.

[18] This function stems primarily from Goodman (2018) 'New Riddle of Induction' and the well known case of grue emeralds.

- Evolving kinds: "natural kinds that have evolved across scientific perspectives and adapted to new scientific practices over centuries."

Here we see that the function of Unanimity can be relaxed to allow for kinds that change their purported observable micro-structural properties.

- In-the-making kinds: "hypothesized viable candidates for natural kinds"

Mill-kinds are characterized by an inexhaustible number of properties that can be ascertained by observation and experiment

Pierce-kinds are a "class such that there is a systematized body of laws about things belonging to this class and 'providing explanation sketches of why things of a given kind have many of their properties' ".

The lawlikeness of natural kinds is not downstream from some prior holding of microstructural essential properties and relations. But it is not a disposable add-on to Mill-kinds either. For without laws, Mill-kinds turn out to be empty kinds. And with laws, even in-the-making kinds enjoy the status of Peirce-kinds.

The final category of natural kinds that Massimi presents are so-called Empty kinds.

- Empty kinds: "putative kinds whose membership eventually turns out to be an empty set."

This final category is intended to demonstrate that we can have projectable kinds despite them not having any underlying instantiated properties. A now famous example of this is the Phlogiston Theory of heat which in its day made projectable predictions of thermodynamic phenomena despite eventually being shown to be superseded by the kinetic theory of heat. Nevertheless we might still want to include Phlogiston as a kind of natural kind, given its ability to make such projectable predictions.

5.3.1 Flow as an *in-the-making* kind

From this discussion of Massimi's account of natural kinds, we can apply this account to the case of TF and ask, which one of these does TF fit into. I suggest that it fits best into the *in-the-making* kind. Massimi used the example of Dark Matter as the exemplar of an in-the-making kind since it is nomologically resilient across various astronomical/cosmological contexts despite not having direct evidence in support of it.

I want to suggest that TF is an in-the-making kind due to being under-girded by HBI, which is what would be as close as one would get to a 'law of nature' in cognitive science, but nevertheless having little direct empirical evidence of it (similarly to dark matter).

This is 'live' science, we don't have the privilege of hindsight, though we can imagine possible futures. One might say that "what if HBI turns out to be wrong?". Under Massimi's account, TF would then become an *empty* kind. "The lawlikeness of natural kinds is not downstream from some prior holding of microstructural essential properties and relations. But it is not a disposable add-on to Mill-kinds either. For without laws, Mill-kinds turn out to be empty kinds. And with laws, even in-the-making kinds enjoy the status of Peirce-kinds."

This framework allows us to contextualise our approach to TF within the perspectival approach and reveals the limitations and affordances of our theorising. We can now move on to see what this account of TF has to say about existing accounts of temporal phenomenology.

5.3.2 Multiple Drafts

The HBI account of our temporal phenomenology aligns with the Multiple Drafts account of our temporal experience provided by Dennett and Kinsbourne (1992). The key insight of the Multiple Drafts account of temporal experience is that "discriminations are distributed in both space and time in the brain. These events do

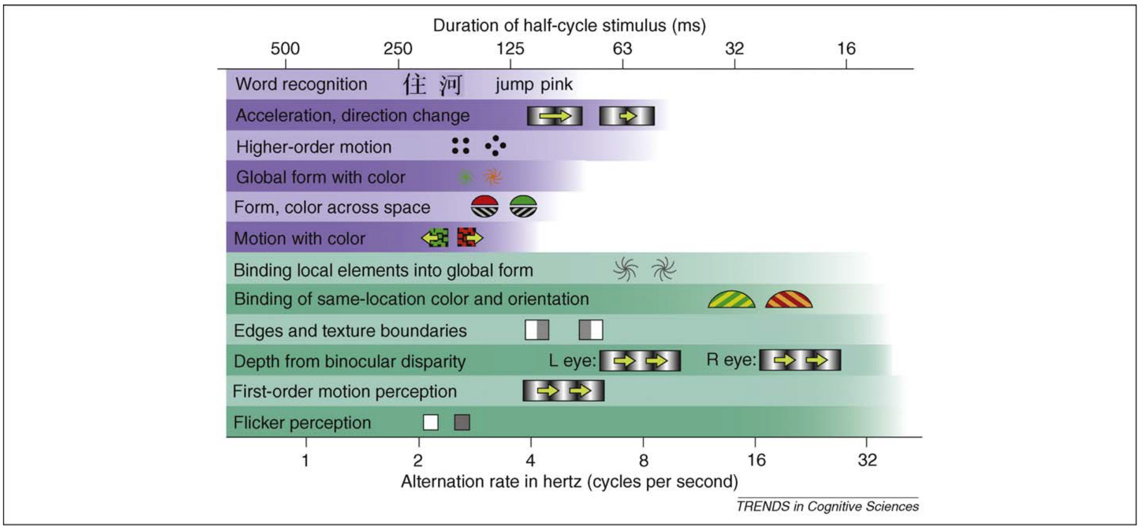

Figure 5.2: Holcombe (2009) presenting work on various limits of distinct visual judgments. Holcombe argues that this suggests (at least) two distinct mechanisms or systems for different visual representations (Seen above in purple and green).

have temporal properties, but those properties do not determine subjective order because there is no single, definitive ”stream of consciousness,” only a parallel stream of conflicting and continuously revised contents.” This is in large part due to how our brains are to ‘bind’ our various temporal experiences and given that this process itself takes time, then there is inevitable ‘smearing’ that takes place. To put it in a phrase, one needs to “distinguish time represented from time of representing” (Dennett & Kinsbourne, 1992).[19] Given the HBI account we can see that the ‘parallel streams’ correspond to the various levels of the prediction hierarchy and the ‘continuously revised contents’ correspond to the contents of the generative models which need not be consistent with or can even override the contents of prior model predictions. Given this account we would also expect different kinds of discriminations to be processed on different levels of the hierarchy and hence correspond to different capacities for temporal discriminations. An example of this can be found in Figure 5.2 showing a variety of different visual judgments having different rates of discrimination. We can see from this that if our brains receive some changing visual scene it must always bind, integrate, and revise a wide variety of different features across different timescales.

[19]For a recent discussion of this and related issues see Hogendoorn (2022).

This approach is motivated by a rejection of a naive picture of conscious representation, what Dennett calls the 'Cartesian Theater'. In our case of HBI this is related to how perceptual experiences are not passively 'imprinted' onto our psyche, rather there is an active prediction, construction and *re*construction which produces our perceptual experiences.[20] "The representation of sequence in the stream of consciousness is a product of the brain's interpretative processes, not a direct reflection of the sequence of events making up those processes." (Dennett & Kinsbourne, 1992). We can see an example of this in Figure 5.3 where accurate trajectory estimates necessarily require re-construction due to variable neural delays for different judgments (comparing colour vs edge detection etc) as seen in Figure 5.2.

5.3.3 Returning to reductionism

The ways in which reductionist accounts of our experience of TF have been formulated in the literature has been to say that such an experience is nothing more than our experience of perceptual motion or change.[21] However, a common secondary move is to say that, given this reduction of our experience of TF to experiences of motion, talk of TF does not give extra explanatory power towards understanding TF.[22] While I agree that that talk of *ontological* flow/passage is not necessary and provides not special explanatory power, I disagree with this second move if we instead understand talk of TF as refereeing to a perspectival phenomenon. While it is strictly speaking the case that the account laid out in this thesis is ontologically reductionist with respect to the phenomenon of TF (ie, we can think of it as being ontologically reducible to B-theoretic facts), what we gain by talk of the experience TF is a kind of explanatory efficiency. We are able to efficiently articulate a complex relationship of embodiment and embeddedness of agents which represent the world in a way that efficiently allows them to intervene in their environment. This is what Dennett (1991) calls a *real pattern*, So while standard reductionists are correct in

[20] That is not to downplay the role of incoming perceptual data in the construction of experience as discussed in Section 4.3.

[21] See Section 1.3.6 for a reminder of reductionist accounts of TF.

[22] See Farr (2020b) for an example of such an argument.

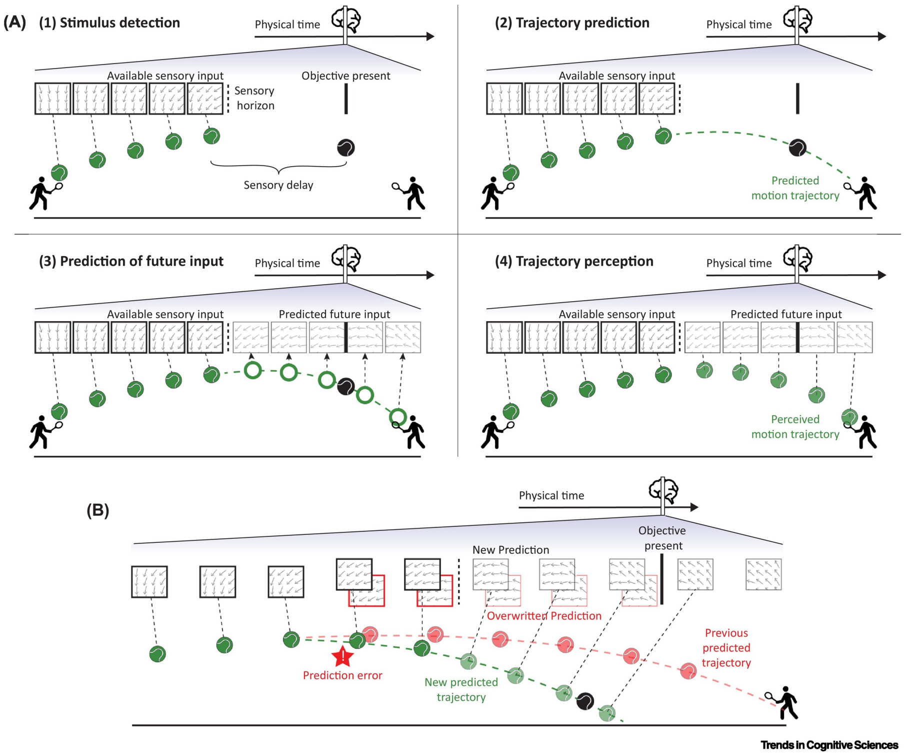

Figure 5.3: Diagram representing the stages of sensory prediction and reconstruction by Hogendoorn (2022) where "(A) Due to neural delays, (1) available sensory input about the position of a moving object lags behind the object's physical position (black), but can be used to extrapolate the object's expected trajectory. (2) This allows future sensory input to be predicted (green open circles), such that perceptual representations of timepoints beyond the sensory horizon can be activated. (3) In this way, perception represents a timeline (4), encompassing the ball's entire trajectory, (i.e., past, present, and future). (B) When predictions do not match incoming sensory input, for example because backspin on a tennis ball causes it to deviate from its anticipated trajectory, prediction error results. In this situation, postdiction mechanisms overwrite representations of past or previously predicted events (red), and new predictions are formed (green). The trajectory that was initially perceived is overwritten, and only the new trajectory is perceived and remembered. Importantly, these post-diction mechanisms satisfy causality because they do not affect past representations, but rather overwrite current representations of past events."

rejecting the claim that TF is required to be located in our fundamental ontology, to fully account for our phenomenology we should not throw the baby out with the bathwater.

The account I am proposing here is then a kind of middle-way between the illusionist accounts and reductionist accounts. I will expand on this point further in the next section but remember that the key difference between the reductionist and the illusionist is that the illusionist thinks that we have a an experience that falsely represents the temporal passage while the reductionist thinks that there is no such experience to begin with and that it is the result of our ordinary experiences of change and motion. In short, I will hope to show that we do have a temporal experience that is distinct from our ordinary experiences of change and motion, but that experience doesn't represent temporal passage, but rather *perspectival* passage.

This tension is well articulated by Bardon (2023) when he distinguishes between illusion and projection with respect to TF.[23] Bardon distinguishes three distinct kinds of reductionist/deflationary accounts of TF[24]:

I. Type C: Direct Projection Account Belief in passage arises from a misunderstanding of some feature of one's own experience as an objective property of the world – i.e., taking some subjective phenomenology of change or continuity as itself objective flow

II. Type D: Indirect Projection Account Belief in passage is an attributional misconception based on our way of thinking about change and/or self-representation in relation to change

III. Type E: Combined Projection Account A complex combination of mechanisms falling under types C and D. In other words, a complete explanation of belief in temporal passage may involve both direct and indirect projection.

The key point that Bardon is trying to draw our attention to is the third case (Type

[23] Bardon uses the terminology of Temporal Passage but the point remains.
[24] Bardon actually distinguished 5 kinds of account of TF but the first two include the previously discussed A-theoretic robust passage realism and Illusionism.

E) where there is a mix of perceptual and cognitive aspects to our experience. This, I think fits extremely naturally with the HBI account presented above since it similarly interweaves perceptual and self-representational aspects that generate our experience of TF. Furthermore the notion of *projection* naturally coincides to the central role that prediction plays in the generation of our phenomenology, that we do not let the world imprint itself onto us, we project our expectation onto it. Miller (2023) roughly calls this view a *veridical passage-less*, given that we live in a block universe but out experience of TF is nevertheless somehow veridical in an important sense. "To be sure, we get to say that our perceptual experiences have a sort of dynamical quality to them, and that this quality is illusory. But it is not really very plausible that that content is one as of robust passage" (Miller, 2023).

To highlight this further let us return to the new well known 'Detector Arguments' by Prosser (2016). The punchline of those arguments being that "the brain is of course a physical system. If no physical system can detect the passage of time, then the brain cannot detect the passage of time. And if the mind is the brain, then it follows that the mind cannot detect the passage of time." Prosser (2016, pg. 35). Given the account laid out in this thesis, it is clear then that we do not *detect* TF (what Prosser refers to as passage), rather we *construct* it. We construct it given the particular cognitive architecture that comes along with our evolutionary needs and affordances.[25] However, much like social constructs, despite being contingent, they indeed have concrete effects on our actions, beliefs and attitudes. Furthermore, given a particular context in which a (social) construct is instantiated, there are then facts about it (albeit contingent facts) that agents within this context can rightly or wrongly agree and coordinate on. This point is evocatively put by Dennett (2013) in discussing Predictive Processing:

> Here is where Bayesian expectations could play an iterated role: Our ontology (in the elevator sense) does a close-to-optimal job of represent-

[25] See Pezzulo et al. (2022) for a discussion of the potential evolutionary origins of predictive processing cognitive architecture.

ing the things in the world that matter to the behavior our brains have to control. Hierarchical Bayesian predictions accomplish this, generating affordances galore: We expect solid objects to have backs that will come into view as we walk around them, doors to open, stairs to afford climbing, cups to hold liquid, and so forth. But among the things in our Umwelt that matter to our well-being are ourselves! We ought to have good Bayesian expectations about what we will do next, what we will think next, and what we will expect next! And we do. Here's an example:

> Think of the cuteness of babies. It is not, of course, an "intrinsic" property of babies, though it seems to be. What you "project" out onto the baby is in fact your manifold of "felt" dispositions to cuddle, protect, nurture, kiss, coo over, . . . that little cutie-pie. It's not just that when your cuteness detector (based on facial proportions, etc.) fires, you have urges to nurture and protect; you expect to have those very urges, and that manifold of expectations just is the "projection" onto the baby of the property of cuteness. When we expect to see a baby in the crib, we also expect to "find it cute" – that is, we expect to expect to feel the urge to cuddle it and so forth. When our expectations are fulfilled, the absence of prediction error signals is interpreted as confirmation that, indeed, the thing in the world we are interacting with has the properties we expected it to have. Cuteness as a property passes the Bayesian test for being an objective structural part of the world we live in, and that is all that needs to happen. Any further "projection" process would be redundant. What is special about properties like sweetness and cuteness is that their perception depends on particularities of the nervous systems that have evolved to make much of them. (Dennett, 2013, pg. 210)

This point is complimented by Ismael (2013) in the context of our temporal experience with what she calls the Temporally Embedded Point of view (TEmP) and the

Temporally Evolving View (TEv).

> This gives us an interpretation of the [...] philosophical images of a world in the process of Becoming, not as images of how the world appears *sub specie aeternitatus*, but as images of how it appears to the evolving point of view of the self-memorializing decisionmaker. There is nothing deluded about this perspective. We're not wrong to think that the past is fixed and the future is open, that our own actions resolve facts that are genuinely indeterminate until the moment of choice. Nor is physics wrong not to recognize any form of Absolute Becoming. The mistake that philosophers who defend an Absolute Becoming make is to reify features of the embedded point of view and regard them as aspects of time itself. But there is an equal and opposite mistake on the other side, which is to dismiss features of the embedded perspective as intellectual confusions. They are not confusions; they are real features of how time appears from the practical perspective of participants in history. (Ismael, 2013, pg. 164)

From these two quotes we can begin to see explicitly how the kind of Combined Projection account by Bardon (2023) might begin to take shape. That the 'expectations of expectations' articulated by Dennett form the basis of the mix of the direct and indirect mechanisms that bring about our experience of TF. Furthermore, as Ismael points us, how such an account can be thought of as perfectly veridical from within such a perspective.

5.3.4 Representing Hypertime

As we saw in the last section, I argued that our experience of TF is in fact veridical, albeit in a world without robust passage. In this section I hope to show how our experience of TF can help us understand some aspects of certain features of A-theoretic intuitions surrounding robust passage, specifically surrounding the idea of

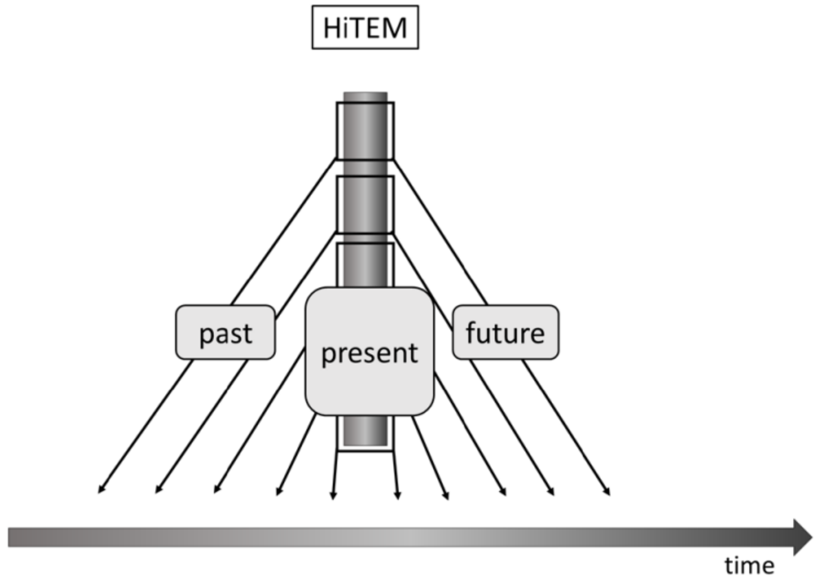

Figure 5.4: Wiese (2017) has the perfect figure describing this

hypertime.

Within the philosophy of time literature regarding the A-theory, we often see mentions of so-called hypertime.[26] This is a theoretical construct used in many A-theoretic temporal ontologies to make sense of a changing present moment. Briefly, for the present to change, it needs to be changing with respect to some other dimension or quantity, call that dimension hyper-time. So at every moment in hypertime, all moments in time are either past present or future. At successive locations in hypertime, which moments in time are present succeeds in turn. The ontological status of hypertime depends on which kind of A-theoretic temporal ontology we are working with since some treat it as just a theoretical convenience that is not ultimately reflected in the ontology whereas others have it on part with the more familiar temporal dimension.[27]

I will argue that the account of TF presented doesn't represent robust passage *per se*, instead it does represent presents a structural similarity to passage in such a way that it partly explains our A-theoretic intuitions regarding passage. Put simply, the

[26] Sometimes also refereed to as Meta-time (Miller, 2013) and Tan (2022). Also see Miller (2018).
[27] For an example of how hypertime is used in a metaphorical sense, see Skow (2012). Also see Law (2019) and Baron (2017a) for further discussion.

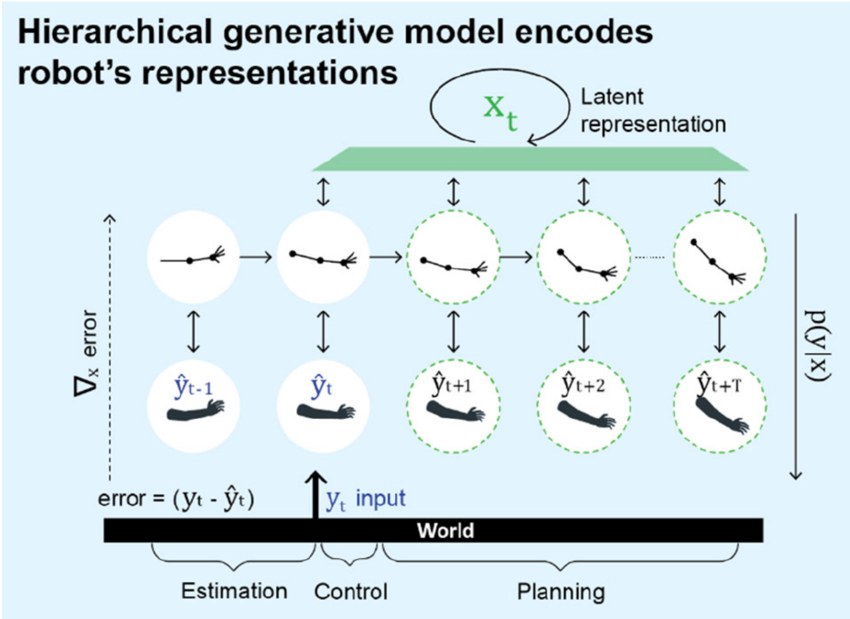

Figure 5.5: Schematic diagram by Da Costa et al. (2022) demonstrating the distinct parallel dimensions of (in the language shown in the diagram) 'world' time at the bottom of the diagram and 'latent representation' time at the top.

way that time is represented in the multilevel hypothesis can be thought of as such a hypertime dimension, one that is conceptually distinct from the underlying temporal dimension. To distinguish the ontological implications of hypertime from what I am describing here, I will refer to this conceptually distinct notion as *model time*. Wiese (2017) in their discussion of predictive processing and temporal phenomenology has a very useful diagram, shown in Figure 5.4. From this diagram see that at any given moment, our multilevel hypothesis provides a model time that incorporates retention and protection of various trajectories (say). Importantly each level of the hierarchy integrates over different spans of time, with lower levels spanning shorter durations and higher levels spanning longer durations. We see a representation of such model time distinct from the underlying temporal dimension in Figure 5.5 similar to Figure 4.4 seen in Section 4.3.2. The fact that we represent a timeline is empirically supported in neuro-psychological research (Grush, 2005; Hogendoorn, 2022) which combines prediction and postdiction.

The fact that model time is conceptual similar to something like hypertime I think can help explain peoples reported beliefs about the nature of time. There has been a variety of recent empirical work regarding the public's folks conception of time.[28] One notable result (of many) is that despite being the majority view, contra the A-theorists intuition, a significant fraction of respondents did *not* conceive of time as essentially dynamical. In short there was a variety of ways that the average person viewed the nature of time. I take this plurality to first cast doubt on the A theorists claim that our experience of time is in-fact obviously essentially dynamical (and not some theoretically loaded construct), but secondly that it provides evidence *in favour* of the account presented in this thesis. How so? Given the account presented here, our experience of TF is one that is intimately mixed with a variety of modalities and cognitive processes, what Bardon (2023) calls a combined projection account. This variety of associations, along with the lack of straightforward language to describe such experiences, would I think naturally lead to a variety of ways people report such experiences.

Back to representing hypertime, the account presented by Wiese (2017) is similar to the account presented by Sattig (2019a, 2019b) in which he characterises our experience of TF as a result of our sense of perceptual *replacement*. How as we go from one experience to another[29] which represent features of the world, we also get a sense of those experiences replacing one another. In the account I have presented here that would correspond to the various levels of the hierarchy representing various durations and updating such representations.

Figure 5.6 is from Sattig (2019a) in their description of what they refer to as 'perceptual change' which in the account presented in this thesis would be the updating of generative models. Notice that there are various perceptual 'windows' that are integrated together to make up our specious present. Sattig describes perceptual change as such (where talk of 'l_i-states' just refers to 'location i');

> S has a temporally extended second-order experience, which has momentary second-order experiences e_1 e_2, and e_3 as temporal parts, with the

[28] For examples see Baron et al. (2022), Hodroj et al. (2024), Latham and Miller (2020), Latham et al. (2021a, 2021b, 2023), R. Lee et al. (2022), and Shardlow et al. (2021).

[29] 'A succession of experiences' as James would put it.

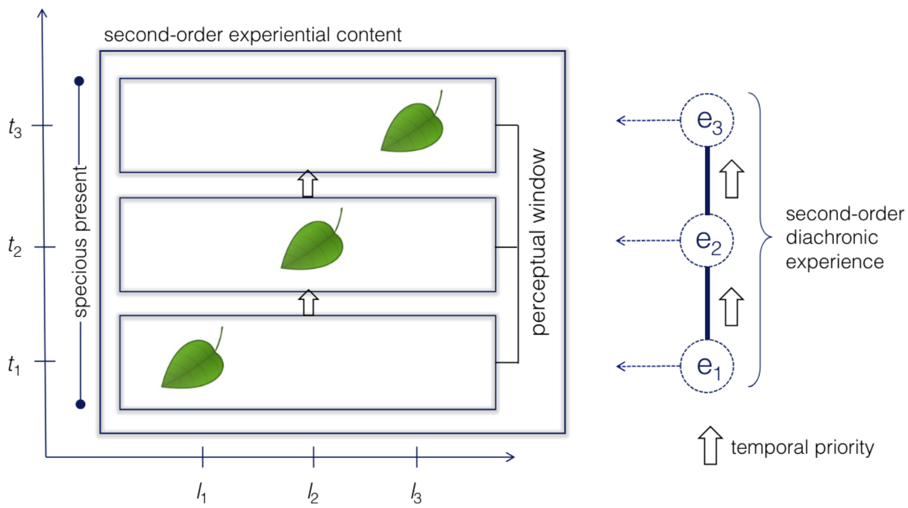

Figure 5.6: From Sattig (2019a) representing an experience as of perceptual change.

> content that her perceptual window displays the leaf's l_1-state before it displays the leaf's l_2-state, and that it displays the leaf's l_2-state before it displays the leaf's l_3-state, where the represented temporal order of the perceptual window-states matches the temporal order of e_1, e_2, and e_3. (Sattig, 2019a)

Sattig similarly is interested in putting forth a *veridical passage-less* account of TF. "Thus, what it would take for a subject's sense of flow to be veridical is for the subject to possess a persisting and changing perceptual window. [...] If a subject in fact possesses a perceptual window that persists and changes with respect to its displayed states over time, then the phenomenally unified whole of a subject's perceptions is a whole that persists and changes in its parts over time." Sattig (2019a)

This succeeds in being a veridical account of our experience of TF, as Miller (2023) writes, " 'Replacement', in this regard, is not a robustly dynamical notion. Representing such replacement need not involve representing that one objectively present experience replaces another when, as it were, the objective present moves, when which experience is objectively present changes. Rather, all that is required is that at different times we have different experiences, and we represent that these experiences have changed. To put things another way, having perceptual experiences (even untensed ones) and then representing that these change, or are replaced or updated, is not to represent that time robustly passes. So if that is what our target phenomenology consists in, then it does not represent robust passage."

To press this point further, the general account presented by Sattig (2019a) and the more specific account presented in this thesis defend a view that our experience of TF is veridical *despite* being compatible with a B-theoretic metaphysics. The mistake however is reifying the representation given to us from the change in multilevel hypothesis into our ontological/objective/third-person view of time, when in fact, like most of our other manifest features of time, it is the product of our particular epistemic circumstances as agents embedded within a particular environment.

To connect it more explicitly with the account presented in this thesis, we can map the temporal parts that make up the perceptual window in Figure 5.6 can be thought of as the lower level predictive estimators within the hierarchy, operating at smaller timescales than the higher level predictive estimators which span across the duration of the specious present. Given this we see that higher level predictive estimators have the capacity to represent the 'replacement' that Sattig suggests since they their predictions depend upon the the bottom up error signals received from lower level estimators. Given the precision of these lower level estimators, this will influence the precision of the subsequent priors, resulting in variable learning rates for each levels of the predictive estimators. Moreover what is represented in these predictive estimators are not merely locations of objects at various times, but *trajectories* which can be overwritten upon updating.[30]

Sattig (2019a) lays out a variety of open questions from his account that I take my account to be able to address. The first of Sattig's questions is "How should the account be extended to address the sense that replacement has a certain direction and occurs at a certain rate?" This question will be addressed in more detail in the next chapter but follows on from the discussion of hypertime. In brief, the way to

[30]Refer back to Chapter 4 for a discussion of how trajectories are represented in predictive estimators.

characterise the rate in this view would be to say something like one model (predicted?) second per second. This accounts for common psychological phenomena of time seeming to pass at different rates in different contexts, given that model updating would similarly undergo different rates in different contexts.

The second question is: "Can this higher-order account of the sense of flow be integrated with a higher-order account of consciousness, so that the sense of flow can be understood as woven into the fabric of consciousness?". I take it that one of the central theoretical virtues of the account argued for in this thesis is the elegant way it answers this question. That is, the mechanism by which TF occurs in the account presented in this thesis underlies not only perception and action, but cognition more generally. It is then very natural to assign the experiences of TF to those various modalities.

Sattig asks three final questions: "How should the account be extended to address not only experiences during a specious present but also connected experiences constituting a continuous stream of consciousness over longer periods? [...] Does the involvement of higher-order mental states in generating the sense of flow render this sense too sophisticated to be available to nonhuman animals with lesser cognitive powers? If so, might non-human animals have experiences as of objectual change without a sense of flow? Is the account supported or undermined by research on temporal experience in the cognitive sciences?" The account presented in this thesis hopefully provides some support to the affirmative of the last question. Regarding the first two questions, these appear to be largely in the domain of future experimental psychology to answer. One might take a stab and answer by noting that there is already a great deal of literature on 'mental time travel' in nonhuman animals and such work would have baring on these questions.[31] I take it that they suggest that a variety of animals from birds to cuttlefish have higher-order functions regarding

[31] See Latham et al. (2024) for a recent philosophical treatment of mental time travel across human and non-human animal cognition. Also, see Schnell et al. (2021) and Birch et al. (2020) for discussions of how (among other things) mental time travel is associated with complex cognition more generally.

their ability to model themselves through time and hence makes it at least plausible that they have similarly higher-order powers that connect to our discussion of TF. A detailed study of these questions would surely need to take into account evolutionary biology to account for the kinds of functions and affordances that are necessary to generate an experience of TF for a given modality.[32]

5.4 Dual Perspectives on Time

Let me finish this chapter by attempting to articulate what I see as the major remaining challenge with regard to the synthesis of two main strands of this thesis, namely that of Neutral Monism (NM) and Perspectival Realism (PR). Despite sharing a thematic resemblance of rejecting any notion of a privileged, global, 'gods-eye-view' of the world, the way that these two approaches go about justifying that rejection, as I will argue, is complementary in a way that is instructive of broader as yet unresolved methodological questions for the philosophy of science.

The target object of inquiry for PR is the *particular* products of scientific inquiry. In contrast, the target object of inquiry of NM is the *broad* conception knowledge itself. On the face of it this does not seem to pose a problem for their compatibility since the target of PR could simply be seen as a subset of NM. So while PR may be an account for the kind of knowledge that humans produce under particular historic and culturally bound tradition with a focus on scientific modeling practices, NM is conceived as the kind of necessary conditions of possibility of knowledge itself (broadly construed).

What is notable is that, when considering the methodologies employed by both of these approaches, this contrast of particular and broad is flipped. Looking at the various methodological tools at the disposal of PR we find that it is very *broad*, drawing on a variety of disciplines from analytic philosophy, to history and sociol-

[32]For more on how evolutionary explanations have been used to understand our temporal experience see Dyke and Maclaurin (2013) and Maclaurin and Dyke (2002).

ogy[33]. As opposed to the methodology of NM is squarely within an philosophical tradition. This is not to say that NM maybe not be inspired by a variety of traditions and diciplines[34] I take it that is this combination of differences in target and methodology that results in the core tension between these two approaches.

That tension is borne out in their different approaches to a kind of metaphysical foundationalism. Despite these two approaches share thematic resemblances, that does not mean that there are not deep tensions in how they execute on those themes. That tension is borne out in their different approaches to a kind of metaphysical foundationalism. Where NM takes itself to be postulating a bedrock metaphysical account of reality, PR, on the other hand, is less ambitious in this respect taking a 'phenomena-first' approach to scientific inquiry, positing phenomena as "stable events indexed to a particular domain of inquiry, and modally robust across a variety of perspectival data-to-phenomena inferences'' 2022, pg. 27. However, how one cashes out such a view of phenomena without appealing to irreducible properties that the NM would be more than willing to.

Here we see how the challenges these approaches face mirror one another. NM would be subject to the kinds of critique leveled at many forms of a-priori metaphysics, while PR is subject to complementary critiques of sneaking in metaphysical concepts it attempts to do away with.[35] I take each of these dialectical tensions to be reflective of deeper open questions in the history of philosophy that trace their lineages back for millennia. Given this, I take them to be outside the scope of this thesis to definitively address. That being said, I mention them here to point to the fact while these approaches serve as a kind of theoretical foundation for the central claim of this thesis, this is not to say that I do not see deep issues here. In fact, one might

[33]I take Massimi (2022) to be another paradigm case of what has been termed integrated HPS Chang (2004) which is marked by commitment to pluralism regarding how science operates and only by recognizing this pluralism can philosophy and history work in tandem to shed light on scientific practice.

[34]See Atmanspacher and Rickles (2022) for a discussion of the varieties of influences that have shaped NM (what they refer to as dual-aspect monism).

[35]See Bica (2022) for a critique of Massimi (2022) who highlights "the rising tension between her modest epistemological beliefs in a plurality of culturally and historically situated perspectives and her ambitious metaphysical commitments towards a primitivist view about laws of nature."

wonder how dependent many of the positive claims I make in this thesis regarding the nature of temporal flow are to these deeper theoretical commitments. I'm not sure, but they are surely not entirely dependent given many of the claims I make are consistent across a wide variety of philosophical views.[36]

5.5 Conclusion

This chapter attempts to locate the account of TF presented in previous chapters within the more general philosophical stance of perspectival realism. First I discussed the kinds of commitments that a perspectival realist holds, along with how it can provide solutions to some canonical issues within philosophy of science, such as how it resolves some of the challenges faced with structural realism. I then discussed how a perspectival realist approach has been applied in the philosophy of time to yet again address long standing puzzles. Finally I argued how the account of TF presented in the previous chapters naturally lends itself to such an approach, characterising it as an *in-the-making* kind, along with showing how, given this account, can provide some explanatory story for some A-theoretic notions such as hypertime.

[36] A notable example I have previously mentioned is that despite positioning this thesis as a vindication of a B-theoretic metaphysics, the central claims made in this thesis are nevertheless compatible with an A-theoretic metaphysics.

Chapter 6

Applications

This final chapter will explore various applications and avenue for further research stemming from the claims defended in the thesis. These applications/research ranges from fields as philosophy, psychology and artificial intelligence research.

6.1 Rate of Flow

Given the account of TF provided in the previous chapter, we can answer a lingering question that has plagued the literature on temporal flow/passage, that being of the question of the *rate* of flow/passage. A first pass comment is to note that this is that any rate described by this account will not be the rate of *robust* passage that the A-theorists are interested in or even the illusionist *representation* of a rate of robust passage.

Price (1996) argues that for time to robustly pass, it must be that it must be reasonable to talk of it passing at different rates. However given that time cannot seem to pass at any other rate than 1s/s the concept of the rate of passage smells of incoherence.[1]. Given that this thesis positions itself within a B-theoretic metaphysics, I am not concerned with arguments surrounding A-theoretic temporal passage and the

[1] We see a similar argument provided earlier by Markosian (1993) and J. Smart (1949). Also see Miller and Norton (2021), Skow (2011b) for a defence of the claim that it is conceivable that time can pass at different rates.

rates therein. However, we we saw in the previous chapter, despite our B-theoretic commitments, there is one sense in which the account presented here can shed light on these issues. Furthermore, I argue that the substantive answers to the question “How fast does time pass?” can not only shed light on distinctive psychological states such as Flow states and depersonalisation states, but also demonstrate the deep links between our temporal phenomenology and the construction of agency.

6.1.1 Learning Rate

Lower levels of the hierarchy of predictive estimators can change the rate at which they update by the modulation of higher level prediction errors. This is called the *learning rate* as mentioned in Chapter 4 and is specifically determined by the *weight* of the prediction which “is given by the relative precisions of the prior and the prediction error, where the precision is the inverse of the variance of the probability distributions. The weighted prediction error is added to the prediction to give the new posterior, which will in turn serve as the prior for the next inference.” (Hohwy, 2017)

Connecting this more explicitly to the learning rate we see that if our perceptual generative model is successful, the weight of higher level predictive errors will be very high, and so there is not as much need to rely on the incoming sensory data (given by the lower level prediction errors) as opposed to the priors and so the learning rate will be slow. Whereas if the perceptual generative model is not successful, this will be reflected in a low weight of higher level predictive errors, and so the priors will be less reliable, needing to rely more on the lower level prediction errors and therefore increasing the learning rate.

As we established in the Chapter 4 our experience of TF is a product of the UH which ties our experience of TF to the updating of generative models. Hence we would expect our experience of TF to be modulated in accordance with the rate at which the updating occurs, known as the learning rate. Given that the learning rate is relatively constant in everyday life, the goal of the upcoming sections is to illustrate cases in which drastic changes occur will be shown to have on our phenomenology of TF and otherwise.

6.2 Variations of Learning Rates, from Flow States to Disassociation

In this section we will apply the discussion from the previous section to two distinct psychological examples. These cases illustrate the extremes of high and low learning rates. I will explore how analysing these psychological states through the lenses of TF and temporal phenomenology more generally can eliminate the connections with such phenomenology to agency more generally.

6.2.1 Flow *states*

Despite being a conceptually distinct psychological phenomenon, the account of TF articulated in this thesis can help explain certain features of what are called Flow *states*, first articulated by Csikszentmihalyi (1975, 2013) and Nakamura and Csikszentmihalyi (2009). The particular features of Flow states that is of interest to us here is the purported altered sense of temporal phenomenology, "distortion of temporal experience (typically, a sense that time has passed faster than normal)" and "merging of action and awareness"(Nakamura & Csikszentmihalyi, 2009). I argue that both features can be thought of under as our brains "trusting the present" through the coming together of affordances and external challenge. There are a variety of examples of this from sport to chess to performances to creative work. In each of these activities ones ability and afforances are dictated by the environment. Importantly these abilities are very narrow in scope. When one is performing music, there are only a very narrow set of actions that will produce the appropriate musical sound. However the task that you are performing must have a degree of challenge since if it is trivial to do (say just doing scales) then there is not sufficient engagement for us to be challenged and hence engaged.[2]

The phrasing of 'trusting the present' is a reference to the title of paper by Hohwy et al. (2016) "distrusting the present" in which a key claim was that there are high-level expectations of change provided by a HBI architecture. However, within a flow state, since it is attainable only through sustained, ongoing deliberate practise, one would expect the prediction error generated from action-perception loops to drop significantly. This is in part because the kinds of activities that are particularly conducive to flow states (sports, games, etc) deliberately and drastically *constrain* the available actions one can make. This results in the capacity for the space of possible actions to be reduced and therefore facilitates the synchrony between an agent's internal states and its environment.

I argue that this all results in high-level expectations of change to be suppressed as the agent's actions confirming the predictive hypothesis becomes more and more robust. From this we can see directly the merging of action and awareness. We can also see how this relates to the purported temporal phenomenology of retrospective duration judgments being shorter than expected[3] since how we track duration would at least in part be dictated by the rate of updating of generative models (textcite). Since this updating has been at least partially disrupted within a Flow state, then we would similarly expect not only our retrospective judgments of duration to be altered but also our presently experienced temporal phenomenology in which subjects within a flow state report feeling that time has 'melted away', as one subject reported "Time passes a hundred times faster. In this sense, it resembles the dream state. A whole story can unfold in seconds, it seems. Your body is nonexistent-but actually your heart pumps like mad to supply the brain...."(Csikszentmihalyi, 1975).

There is existing discussion on whether instead of describing the flow state as resulting in time seeming to pass at a faster rate, rather there are various other reports

[2] Another important feature of Flow states is that they are almost always driven my *intrinsic motivations*. Its not clear whether the intrinsic motivations are caused by the intrinsic value of the flow states themselves or that they are a distinct and necessary precondition.

[3] For experimental work in this area see Conti (2001).

that characterise it as a kind of 'timelessness' or 'a-temporal'.[4] An important distinction to be made is between retrospective duration judgments and experience of TF. Both can occur but will have distinct.

A related psychological phenomenon occurs during meditative states. There is a wide literature on the effects of meditation on time perception, particularly retrospective duration judgments (Kramer et al., 2013; Sedlmeier et al., 2020; Wittmann & Schmidt, 2013). Thönes and Wittmann (2016) also investigated subjects experience of the passage of time *during* the meditative session itself, which I take to be at least related to the experience of TF. They write " On the basis of the notion of embodied time perception, we expected a slowed passage of subjective time in the yogic meditation condition compared to in the music condition. If subjective time depends upon the registering of bodily feelings, the body-centered yogic meditation should lead to a stronger awareness of bodily feelings and thus of time. Subjects who are more aware of their bodily feelings would also be more aware of time and therefore subjective time would go by more slowly. However, it is anecdotally known that the time of meditation passes quickly for meditators who get easily absorbed by the meditation experience; this is due to an experienced loss of self and time during meditation" (Thönes & Wittmann, 2016). This latter kind of experience seems to be closer to the flow states described above since it is with experiences meditators who have experience and expertise in the meditative practise whereas the former description seems to describe the a top left region of the challenge and skill diagram from Csikszentmihalyi (1975) that describes a lack of skill relative to a given challenge (in this case the challenge is the act of meditation). This results in the affect of worry which under our HBI framework would result in a low weighted prediction error, resulting in a higher learning rate, resulting in what the authors describe as more "registering of bodily feelings". In the empirical work that Thönes and Wittmann (2016) performed they found that during meditation, subjective judgments of time

[4] See Mainemelis (2005), Mainemelis (2002), and Mainemelis and Dionysiou (2015) and for a discussion of the empirical work in this area and Metzinger (2020) for a recent philosophical discussion.

passed quicker than compared to a control group suggesting that they had some experience with meditation.[5]

Finally it has also been argued that phenomena such as fidgeting are a mechanism by which agents regulate self evidencing. Perrykkad and Hohwy (2020) argue that since "Fidgeting is often self-stimulatory and reflexive, reflected in the tight causal loop and involvement of few hidden causes, with good robustness across environmental contexts" then "Fidgeting leads to uncertainty reduction using a policy for action that involves only few hidden causes and which therefore furnishes a highly precise mapping of actions to outcomes."

6.2.2 Depersonalization and Psychedelics

If flow states are one potential result of some threshold of low prediction error and hence low learning rate, what might be on the other end of the spectrum? What kind of psychological states might result from high prediction error/learning rate and what kind of temporal phenomenology might result?

The other side of flow is in one sense a similar kind of loss of the self and agency, but through different means compared to flow states. The paradigm cases of such high prediction error states are found in radical ego-dissolution associated with psychedelic experiences and other depersonalisation disorders (Gerrans, 2019, 2024; Letheby & Gerrans, 2017; Limanowski & Friston, 2020). The distinctive difference between these states and the previously discussed flow states is there is a more radical *disconnection* with the agents internal model and environment as opposed to the *merging* of agent and environment.[6] This is unsurprising once we view it from a PP/Active inference framework since the key variable that we are comparing across each case is the *prediction error* comparing the agents model of its sensory inputs to the sensory inputs themselves. Carhart-Harris and Friston (2019) articulate an

[5] Examining the participants of the study shows that more that $\frac{1}{5}$ already had experience with meditative practise.

[6] We will see in section 6.2.5 that in such cases the very distinction between agent and environment can be thought to break down.

explicit framework of understanding such states within the HBI framework which they call RElaxed Beliefs Under Psychedelics (REBUS). This REBUS model appropriately predicts on the basis of neurobiological evidence that such states are the result of relaxed priors which result in higher learning rates.

Deane (2020) analyses such experiences using an active inference framework and specifically addresses temporal phenomenology. Their analysis follows the following three steps. ”First, a view of the self-model is proposed as arising within a temporally deep generative model of an embodied organism navigating an affordance landscape in the service of allostasis.” (Deane, 2020) This point reiterates the more general point of HBI accounts in which the agent not only model external stimuli but also *internal* processes. This model is distributed across various levels of the predictive hierarchy, with each level predicting across various spatial and temporal scales. These various scales of prediction allow for large and small timescales to be integrated together such that agents can efficiently navigate complex environments.

“Next, a view of the action of psychedelics as lowering the precision of high-level priors within the generative model.” (Deane, 2020) As previously mentioned, lower precision priors can be thought of as the model being very unsure of what input it may receive. This is supported by the aformentioned REBUS model by Carhart-Harris and Friston (2019). “Finally, the relaxation of high-level priors is argued to cause a “collapse” in the temporal thickness of the generative model, resulting in a collapse in the self-model and a loss of the ordinary sense of being a self.” (Deane, 2020) Here temporal thickness simply refers to the generative model predicting over various timescales. Why would a collapse of temporal thickness result in a collapse of our ordinary sense of self? Well as previously mentioned a vital aspect of our sense of self under the HBI story is self-regulation and self-evidencing, the matching of predicted expectations with internal processes. Given a collapse of temporal thickness would inhibit the ability to make such predictions, they would similarly inhibit the maintenance of the self.

6.2.3 Agency and Temporal Phenomenology

We have seen in the previous sections that an examination of the temporal phenomenology of a variety of psychological case studies has led us to see the intimate link between our temporal phenomenology (and particularly that of TF) and notions of *agency*.

In the Flow states example we saw a kind of 'overfitting' of priors such that the learning rate is reduced. We can interpret this overfitting as kind of loss of agency. In a flow state the agent is in such harmony with their environment that there is no need for a weighing up of options and reacting to stimuli, there is, as Nakamura and Csikszentmihalyi (2009) says "merging of action and awarenes". As mentioned in Young (2022) account of TF where they argue that our experience of TF arises from feeling ourselves as being the source of ones actions. Here we see how the account presented above *explains* this account and subsumes it into a more general account of our experience of TF. This is the result of the underlying unity of perception and action under the HBI framework.

It seems then that deliberate agency arises from a delicate balance between responsiveness and steadfastness, from reaction and prediction, from internal and external influences. Agency it seems, viewed as a product of evolutionary adaptation, is the means by which organisms manage their goals and affordances.[7]

6.2.4 Active Inference and Markov blankets

One of the important theoretical tools used in active inference is that of a *Markov Blanket*. Parr et al. (2022) frame the use of Markov Blankets as the *high road* to active inference since it begins with abstract statistical principles such as the Free Energy Principle and then uses Markov Blankes as a normatively solution for how organisms can efficiently fulfill such abstract principles.[8] Parr et al. (2022) define a

[7]See Craig (2009) for an influential review of the neuroscience literature which connects time perception, agency and self-awareness.

[8]This is opposed to the 'low road' which explicitly beings with a concrete notion of a brain attempting to generate accurate representations on its environment.

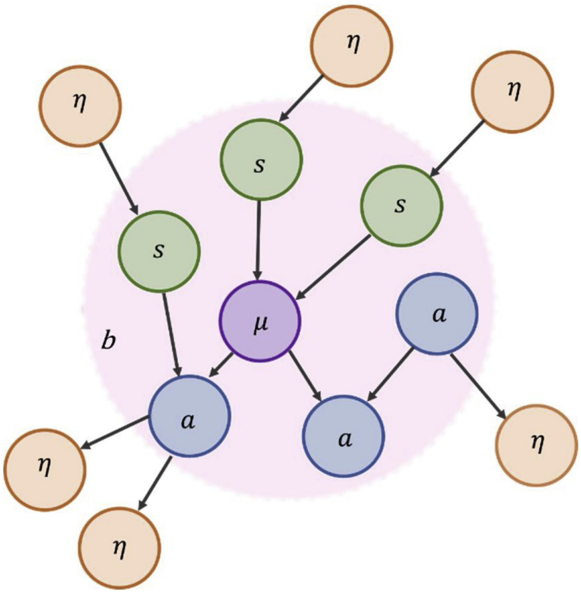

Figure 6.1: Schematic representation of causal variables making up a Markov Blanket from Hipólito et al. (2021). Variables labeled s represent sensory states, a represent active states and μ represent internal states which by construction are conditionally independent from external states η.

Markov Blanket as follows "A Markov blanket for a given variable comprises a subset of those that interact with it. If we know everything about this subset, knowledge of anything outside this subset does not increase our knowledge of the variable of interest." Where 'variable' here might mean the state of an agents generative model. A schematic diagram of the various variables that make up a Markov Blanket can be found in Figure 6.1 by Hipólito et al. (2021).

For our purposes one thing that the Markov blanket representation highlights is the particular causal embeddedness of agents. They provide a formal framework for expressing how agents are influenced by, model and influence the world around them. They do this by providing a formal framework for theorising about cognitive structures in the brain and about the perspectival nature of our cognition and theorising more generally.

We can see how Markov blankets are an instantiation of the general notion of an agent given from Rovelli (2007) who defines it as "The agent is the system whose physical links are neglected in a given account."(Rovelli, 2007), in particular Rovelli is interested in what he calls Independent agents: "a system governed by an internal

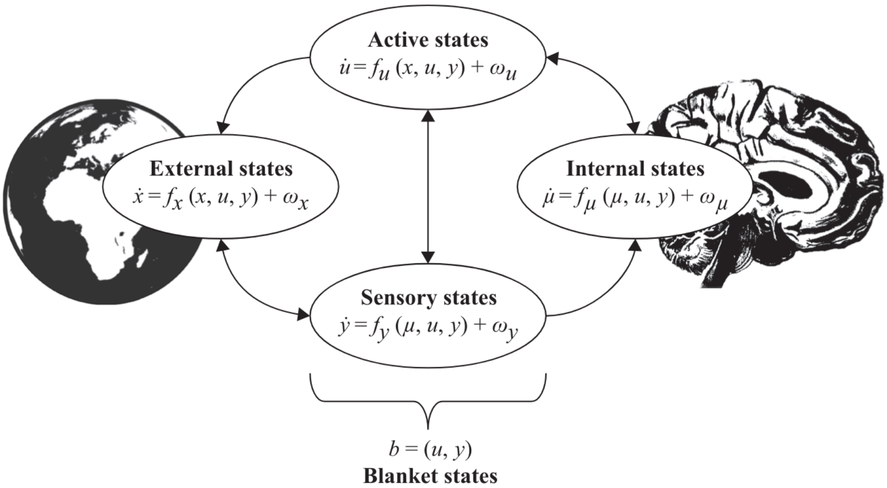

Figure 6.2: Representation of dependencies between Blanket states (active and sensory), Internal states, and External states (Parr & Friston, 2017) where the ωterms are random noise.

(deterministic or probabilistic) dynamics, too complex for us to reconstruct."

I take it that the formalism of Markov Blankets connects naturally to puzzle in the philosophy of time of the apparent shared present. As suggested by Callender (2008) and Dorato and Wittmann (2015) despite Relativity strongly suggesting that that there is no objective shared present, it nevertheless *seems* to us that there us since we operate at sufficiently low velocities that on local length scales it is an effective coordination strategy for organisms like us to assume a shared objective present. As I mentioned I take the formalism of Markov Blankets to provide more detail to this general story in the following way. While the variables described by a Markov Blankets are agnostic to their spatial distribution,[9] given that causal influences are local[10] then it follows that for an agent to effectively model their environment they need only model the local external states. As such each agent need only model their local now patches comprised of their local causal variables. Both Callender (2008) and Dorato and Wittmann (2015) discusses the varieties of temporal integration that occurs in our brains, when constructing its local now patch.

[9]See van Es and Kirchhoff (2021) for a discussion on how the application of Markov blankets can be used to define biotic systems as a system that *self-individuates*.

[10]Given we deal with macroscopic systems without worrying about any potential non-local Quantum effects.

6.2.5 Ecological-Enactive approaches

The previous section focused on the formal apparatus of Markov Blankets which helps specify the causal embededness of agents in their environment. This general strategy within cognitive psychology A growing set of related approaches to cognitive psychology have been labeled together as 4E cognition: embodied, embedded, enactive, extended. These labels describe a variety of ways we should understand the necessary features of cognition in light of a purely computational view. Namely that it is misleading to describe cognition with analogy to a computer, running software on hardware (where the two are conceptually separable). Instead there is a focus on locating the agent within its larger context, whether that be a body (embodied), its environment (embedded), its actions (enactive) and its tools (extended). While PP can and has been framed in the computational view, there has been a growing push among proponents of PP to frame it in 4E terms. [11]

One of the primary ways PP connects to a more general enactive-ecological approach is in how one interprets the generative model. Instead of a familiar computational algorithm, the generative model described by PP can be instead thought of more holistically, spanning across the organism. "According to the enactive approach, spatially contentful, world-presenting perceptual experience depends on implicit knowledge of the way sensory stimulations vary as a function of bodily movement." (Briscoe et al., 2023). Here "implicit knowledge" can be thought of as effects of the priors of a generative model. "The free-energy principle does not apply to brains or epistemic agents, but to embodied living systems as a whole" (Bruineberg et al., 2018). K. Friston (2013) put it even more succinctly with "an agent does not have a model of its world - it *is* a model". Given the account of TF I have articulated, where TF arises chiefly from the updating of such world models, I think one can say that TF is the subjective experience that is the hallmark of an agents *connection to the world.*

"In adopting this enactivist account of the brain as embedded within a larger

[11] For examples of such views see Clark (2015, 2016) and Kirchhoff (2018).

brain–body–world dynamic, one arrives at the view that the phenomenological world of experience is not just realized in neural space but is a fundamentally relational phenomenon" (Kirchhoff, 2015). This sentiment echoes and vindicated the more general discussion of phenomena in Chapter 3. Given its intimate connection to PP, I take TF to be *the* relational phenomenon *par excellence*.

6.3 Artificial Intelligence systems

Given the account of TF presented in this thesis, TF is not only not limited to humans, mammals or even other animals, but in principle could be experienced by an artificial agent that we could construct. However, as discussed in particular in the last section on embodied, ecological-enactive approaches to PP, not any kind of agent will do. Namely TF necessitates a deep connection between action and perception.

This section will examine some practical advantages (both epistemological and ethical) along with some broader philosophical lessons that one can draw in the development of a variety of AI systems in the light of the results of this thesis. The contemporary AI systems I have in mind here are often refereed to as Deep Learning Neural Networks[12] which refers to a particular computational architecture that will be contrast with the Active Inference architecture.

6.3.1 Practical Advantages

The practical advantages of Active Inference frameworks compared to contemporary AI systems can be categorised in two (broad) kinds, epistemological and ethical. As we will see the solutions to the former influence the latter so let us start with the epistemological advantages. Da Costa et al. (2022) suggest several promising advantages that robotics based on Active Inference architecture can have. Some of these include Accurate and robust state tracking, Adaptive model-based and shared

[12]Sometimes more generically also referred to as Machine Learning (ML) systems.

control, Learning and grounding,

The final advantage of Active inference based robotics that Da Costa et al. (2022) highlight is operational specification, safety and explainability. Explainability has recently become a great concern for contemporary AI systems.[13] This concern is born out of both epistemological questions (for example, what are the mechanisms by which the systems arrives to the decisions its making?) and ethical concerns of AI systems being used in broader social, political and economic contexts (eg is this AI system inappropriately biasing a particular group of people in its decision making?). This has been made difficult with the recent advent of so-called Deep Learning neural networks which are often contrasted with so called Good Old Fashion AI (GOFAI). Where GOFAI uses explicitly coded symbolic manipulation, contemporary deep learning neural networks which do not involve explicit symbolic manipulation specified by the programmer ahead of time, but rather involve the training of a large network of nodes with weighted connections. Such systems effectively become black boxes with respect to how internal processes generate outputs since any given decision is the result of the firing of 10's or even 100's of billions of nodes which cannot straightforwardly be translated into analogue of an explicit symbolic algorithmic. A popular example of such a system is ChatGPT developed by OpenAI which is an example of a Large Language Model (LLM) which is trained upon and generates strings of natural language text once a prompt is input from a user.

These developments come from a long ongoing research program to create robotic systems that can effectively manage complex real world tasks. A key aspect of the challenge is captured buy the well know 'Moravec paradox',[14] which was the insight that while GOFAI excelled at certain tasks well beyond human's capacity, seemingly basic perception and mobility tasks were much more difficult for such

[13]See Adams (2023), Shin (2021), Peters and Carman (forthcoming), Xu et al. (2019), Parr and Pezzulo (2021), Pezzulo et al. (2024) for various recent philosophical discussions of explainability and interpretability in AI.

[14]See Moravec (1988) for an influential articulation of this phenomenon.

systems to perform. The 'paradox' is that tasks that seem straightforward and trivial for humans like identifying and properly manipulating objects in an environment were found to be extremely difficult for AI systems to perform.

The advantage of an Active Inference architecture as opposed to contemporary deep learning neural networks are that they can have more explicitly model causal structure. Da Costa et al. (2022) argue that "the generative model can be specified as a directed graph (i.e., a Bayesian network), which entails the causal relationships between agent's representations". Examples of such graphs (sometimes also known as factor graphs) can be seen in Figures 4.3. This explicit structure allows for clearer interpretability of the systems decision making process, such as counterfactually verifying the effects of different prior distributions on decision making, or the effects of new data. Such interprebility dovetails into the ethical considerations of AI systems. If AI systems are implemented in public decision making contexts[15] One of the core ethical motivations for robust interprebility of AI systems is the desire for *explanations*. If an AI system is to be involved in decision making regarding ethically/socially/economically/politically loaded choices, then we want those decisions to be responsive to *reasons*. Currently no such reasons can be extracted when a deep neural net decides to grant a loan to one person and not another or sentence someone to a 10 year sentence vs a 5 year one. Such desire for reasons can be linked to a variety of ethical commitments surrounding accountability of such systems. These might include the examination of potential biases in such decision making, to general transparency with regards to assessing whether these systems are using only relevant data/reasoning to arrive at a given decision.

Additionally, due to the fact that active inference models not only model their environments but also their *own selves*, this enables them these systems to in principle report on the covert internal decision processes that led to particular outcomes (Albarracin et al., 2023). Parr and Pezzulo (2021) provide an example of such a sim-

[15] Many AI systems are already implemented across a wide variety of decision making contexts. For discussions of such examples see Kolyshkina and Simoff (2021) & Müller (2023).

ulated agent in an environment where it is initially uncertain about its environment, and has to make choices to learn. As various stages of the process the agent can be queried and report and explain its beliefs and actions accordingly. Additionally it has been suggested that it is conceivable to append this system with an LLM's to further translate these internal processes into natural language (Albarracin et al., 2023).

As Pezzulo et al. (2024) put it "generative AI is limited to generating content (images, code, or text) of the type that we would generate given the same prompt or context. Conversely, active inference is in the game of generating the causes of content in the service of action selection, also known as 'planning as inference' ".

6.3.2 Artificial Flow

I have argued in previous sections, the way that agents with a HBI cognitive architecture model the world is inexorably tied to the way in which agents process temporal representations. Given that one of the key distinguishing differences between Active Inference systems and Contemporary Deep Learning systems is planning. A vital component of planning is updating such plans based on feedback. Such updating is the capacity that grounds TF within human experience. Therefore if we are interested in creating artificial agents that can be effective in real world settings, we need to attend with great detail to the ways in which they represent such temporal features. To put it bluntly, it seems that to make sure that robots that are effective, then they ought to be able to track the flow of time.

Reynolds (2024) connects PP and Active Inference to Dreyfus' critiques of GOFAI approaches to artificial intelligence.In short PP (and presumably artificial systems build using PP) is better interpreted as an ecological-enactive approach to cognition (as discussed in Section 6.2.5) rather than the more conventional computational approaches. "A key difference between the two approaches is that, although generative AI learns to provide a response when prompted, active inference associates those responses with meaning that is grounded in sensorimotor experience: the words in the question and response about 'going north' or 'south' are associated with the potential for (and the prediction of) movement in physical space – and engages neuronal processes involved in guiding movement in space and predicting its multisensory and affective consequences." (Pezzulo et al., 2024). This grounding in sensorimotor feedback is at the core of enactive approaches to cognition, which is to be contrasted with a merely discriminate/pattern matching model[16] of current deep neural network systems.

6.4 Conclusion

This section attempted to demonstrate the variety of applications, both philosophical and practical of the general story presented in this story. I take these applications to themselves be a vindication of the perspectival nature of account provided in this thesis. Namely how depending on the task at hand this approach can be applied in a variety of ways. We saw how examining this particular temporal experience led to a deep connection to perception and action. This unified account provides a explanatory framework for seemingly disparate psychological states. It also illustrates the central role of embodiment that has had a resurgence in contemporary cognitive science. Finally these provide a clues for designing artificial systems that are not only more human but also more ethical and efficient.

One theme that has emerged throughout the thesis is that the perspectival nature of our inquiry leads to a richer set of concepts to describe the world than one might expect from a 'third-person' representation. This is most clearly seen in the central focus of this thesis regarding reconciling an apparently bare B-theoretic temporal ontology with our rich temporal phenomenology without dismissing that apparent richness as mere illusion. This richness is born out of the irreducibly perspectival nature of scientific representation. These perspectival features range from the ab-

[16] I borrow this phrasing from Clark (2016)

stract, such as dual-aspect monism discussed in Chapter 3, to the concrete, such as culturally contingent practises.

From this it becomes clear that incorporating such perspectival features into the representation of artificial robotic systems it crucial, specifically a representation of them-self in the environment, their affordances, and how such affordances make a counterfactual difference in their environment.

Chapter 7

Conclusion

The goal of this thesis was to develop an account of our experience of temporal flow that is veridical, yet consistent with a B-theoretic temporal metaphysics. This initially seems contradictory since one of the distinctive features of the B-theory is that it lacks any notion of temporal passage for our experience of TF to correspond with. The way I resolve this apparent contradiction is though proposing a perspectival account of the concept of TF in two distinct senses of the word perspectival. The first is that the dynamic quality of our temporal experience is the result of the perspective of agents embedded in an environment. The second sense of perspectival refers to how we interpret our philosophical/scientific theories in light of concerns of realism. Let me now summarise the main claims from each chapter of this thesis and how they build on one another to meet these aims.

Chapter 2 first problematized the strategy of incorporating A-theoretic into our physical theories by examining novel accounts within fundamental physics to do so. The limitations of a purely 'objective' (non-perspectival) description. I attempted to show that despite efforts from Physicists like Lee Smolin and Fay Dowker to incorporate A-theoretic concepts into our physical theories, either they are unsuccessful in doing so, or even if it was successful that it would make no difference in accounting for the manifest dynamic experience of time that was (partly) motivating this move.

Notably with Lee Smolin's work, I examined his proposals regarding the distinction between Law and State, Novelty and Qualia.

In Chapter 3 my primary goal was to take a step back to analyse TF as a metaphysical on its own terms. This approach led to an analysis of phenomena from two distinct trajectories, the first is in what I term *subjective phenomena* in which the term points to features of our subjective experience (eg. Kantian phenomena). The second trajectory was what I term *objective phenomena* in which the term points to features of states of affairs in the world. I argued that these two conceptions of phenomena for a kind of dialectic in the history of philosophy and that TF is a paradigm example of the dialectical tension between these two conceptions of phenomena. Given this, I tentatively propose a different conception of phenomena to resolve this dialectical tension, and hence to provide a convincing articulation of how one might approach the phenomena of TF. This approach takes advantage of a branch of metaphysics called Neutral Monism, or more descriptively called dual-aspect monism. I argue that conceiving of phenomena as fundamentally neutral, with objective and subjective *aspects* allows for both philosophical and methodological insights. Those being that it does justice to the seeming elusiveness to the subjective phenomena, while incorporating the philosophical advantages of epistemic structural realism

Chapter 4 marks a turn away from metaphysics, and towards a scientific proposal. Namely, a proposal for a psychological mechanism which can begin a positive account of our experience of TF. In it, I propose the Updating Hypothesis (UH) which states the content of our experience of TF is the result of the updating across the hierarchy of generative models within a Predictive Processing framework. From this I argue that this amounts to an experience as of higher-order change similar to the account presented by Sattig (2019b). This leads to what I take to be a success of this account which is to show that our experience of TF is *veridical*. This is in contrast with the standard B-theoretic illusionist or error theoretic accounts TF which either assume that such an experience is non-veridical or non-existent.

Chapter 5: bring together the account of phenomena with a broader conception of perspectival phenomena. This chapter attempts to locate not only how TF is itself a perspectival concept, but also argue that the way that we should understand the various accounts within the philosophy of time in Perspectival Realist terms as articulated in Massimi (2022). I develop on the results of the previous chapter to argue that contra to the A-theorists claim that we ought to somehow detect passage, under this view we *construct* it. Despite this this does not jeopardise its veridicality since a great deal if not all of our conscious experiences are similarly constructed.

Finally in Chapter 6 I discuss various applications and directions for further work, going from philosophical to scientific and back to philosophical. It begins with addressing a standard puzzle within the philosophy of time which concerns answering what rate does time flow? Usually this would lead down a metaphysical morass, however in this account this question amounts to asking at what rate does the updating of various levels of the predictive hierarchy occur, otherwise known as the *learning rate*. This naturally leads to the question of what kind of states do very high and low learning rates produce? I argue that low learning rates are indicative of meditative flow states in the sense articulated by Csikszentmihalyi (1975, 2013) and Nakamura and Csikszentmihalyi (2009) and high learning rates are indicative of dissociative and hallucinatory states. What is notable about both of these states is that both result in a dramatic loss of agency, the former from a merging of agent and environment, and the latter from a radical disconnect. Here we arrive at the final philosophical application. This demonstrates the intimate connection between our temporal phenomenology and our capacity for agency.[1] Where both TF and genuine agency both arise from a happy middle-ground of predictive accuracy. Finally I end this chapter with an examination of how such an account can be applied to artificial agents and the potential epistemological and ethical advantages that would arise.

The way that this thesis has attempted to address TF is similar to how the concept of *elan vital* or the soul seemed necessary to account for the function of life itself.

[1] For another example of such a discussion see Ismael (2013).

Similarly, this thesis has hoped to show that the dynamic quality of our temporal experiences do not require any analogous metaphysical addition by the A-theory to get off the ground. Again, that is not an argument *against* the A-theorist, I have hopefully conceded that there is even reason to think from contemporary physics that an A-theory-like account of time is still on the table. Instead I have argued that if we are in the business of accounting for the dynamic quality of temporal experience, such accounts need not factor into the explanation we provide.

I take one of the lessons from perspectival realism as it applies to the philosophy of time is that the apparent incompatibility of the A and B theory can be interpreted as different *windows onto nature*. As Massimi (2022) puts it "Perspectival models represent a given target system — phenomenon of interest—to the extent that they allow different epistemic communities to make relevant and appropriate inferences about what is possible concerning the phenomenon." So for a physicist modeling the phase space of a system to understand its counterfactual behaviour under various circumstances, something resembling a B-theoretic representation is apt. However for an agent navigating its environment, finding resources and avoiding danger, an A-theoretic representation is apt. This sentiment has already been discussed by Ismael (2013) with her distinctions of a Temporally Embedded Point of view and a Temporally Evolving View. Note how each are *views* on the world, not mutually exclusive states of affairs. Neither contradicts the other, in the same way that my view of a map does not contradict my view of the street. So a better way to frame debates within the philosophy of time would be instead of saying "which is the correct description of time, the A-theory or B-theory?", but rather say "under what conditions might it be fruitful to adopt an A-theory over a B-theory?". Such pluralism is echoed by Chang (2012) who argues that this pluralism, rather than a liability for scientific progress, is an asset.

One might still have a lingering preference for 'global' representation rather than a 'local' one. Take the representation of time using the Einstein Field equations that provides the frame-independent structure of spacetime. There are two things to say regarding this preference. Firstly even if we think that such a representation is possible, that does not de-legitimise the local one, for the reasons discussed at length.[2] Second one might respond by saying that we have reasons to think that such a global representation may not end up being possible. Here I have in mind the Kochen-Specker theorem and Wigner's friend experiments arising from quantum mechanics,[3] and more generally the deep relationality found in approaches found in RQM and QBism[4] where facts are irreducibly relativised to a particular observer.[5] This paints a picture of the world in which no true global representation is possible, rather the local, observer dependant facts are privileged. This is all to say that the *a priori* preference for global/observer-independent representations of the world over perspectival ones need not apply.[6]

Magnus and Callender (2004) in their discussion of the realist/anti-realist debate suggest that instead of addressing realism in science wholesale, instead to assess particular instances/claims of realism by providing "retail arguments that attend to the details of particular cases." My hope in this thesis is to have provided various details regarding the particular case of agents like us and how such details provide as solid a base as one can expect for a realist claim regarding TF.

I take one of the key lessons from a perspectival realist view when applied to the philosophy of time is one of a pluralist view of the world that is continuous with the scientific enterprise. Given that I take one of the primary goals of the philosophy of time is to understand the relationship between our experience of time and the description provided by out best (meta)physical theories then this is just as much a scientific question as it is a philosophical one. Moreover I hope that this thesis was an

[2]See the quote my Ismael (2013) in Section 5.3.3

[3]See Isham and Butterfield (1998) for an in depth philosophical and technical discussion of the Kochen-Specker theorem. In short it states that "no global valuations exist if the dimension of the Hilbert space $\mathcal{H}$ is greater than two" (Isham & Butterfield, 1998, pg. 2672). Also see (Bong et al., 2020; Brukner, 2018) for detailed expositions of Wigner's friend type results.

[4]See Section 2.4 for a discussion of these approaches.

[5]Whatever the term 'observer' might refer to given whatever approach to quantum mechanics one chooses.

[6]For further discussion of notions of objectivity in the light of the perspectival features of quantum mechanics see Evans (2020).

example of the kind of productive dialogue that philosophical and scientific accounts. Where such dialogue can provide raw material for each respective discipline to build upon.

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