THE OPENNESS AND CLOSURE OF THE PAST AND FUTURE

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I, Anaïs Rebecca White, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Abstract

In this thesis I investigate the claim that the future is in some sense 'open', with a view to giving a lucid and useful definition that is currently absent in the literature. To do this, I propose a four-part taxonomy to explain the senses that the future might be open for closed: ontological, nomic, semantic, and epistemological.

This approach allows me to do two things: firstly, I systematically investigate each sense of openness towards both the past and future, noting both the logical possibility and plausibility of their combinations along with any temporal asymmetries they may be used to justify.

I argue that we should consider any account of openness holistically by specifying a position of openness or closure for each of these senses, and develop a framework for doing this. Each sense of openness and closure has corresponding philosophical views, and I explore their impact on the plausibility of combination with other senses. This generates new insights into both the views themselves and the commitments to combinations of openness and closure they entail.

Impact Statement

The key impacts my research will make are firstly to contribute to the literature on the openness of the future in philosophy, but secondly to develop a framework of investigation that may be used elsewhere in philosophy.

Regarding the first impact, there are two key deficiencies in the current literature regarding the open future: a lack of a clear definition of the openness and closure of the future, and lack of a holistic analysis of the ways in which the future could be open or closed.

One of my tasks in this project is to provide a more lucid definition of the open future, using a four-part taxonomy. I do this by systematically investigating each sense of openness and closure, both in the future and past directions. Considering the past direction allows us to see the implications for a whole potential view's ontology, metaphysics, semantics, and epistemology. In the case of a mismatch, it is important to be able to explain and justify the asymmetry between views.

The second is to argue that when discussing the openness of the future, we should consider the view holistically using such a taxonomy. This is because taking a stance on the nature of one of these aspects of openness has an effect on the plausibility of combining it with certain philosophical views within other aspects. This allows me to assess claims made in the literature and explain or dissolve putative problems (as I do with Markosian (1995)).

Regarding the second impact, the four-part framework I use based on different areas of philosophical enquiry: ontological, nomic, semantic, and epistemological. For each of the senses of openness and closure, there are philosophical positions related to them, which I explore in the thesis. For example, there are five views regarding the laws of nature that I consider with respect to nomic openness. In investigating their combination with other senses of openness and closure of the past and future, I show that some of these views generate an incompatibility with another sense of openness I investigate which would be seen when considering the view alone.

Furthermore, using this taxonomy allowed me to systematically investigate the topic, and there is potential for such a taxonomy to be used in investigating other philosophical areas such as metaphysical fundamentality or reductive explanations in science.

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CONTENTS

INTRODUCTION

Thinking about the future is harder than we give ourselves credit for. It is something that is very important in our day to day lives, especially in our reasoning — so much so that we don't often realise the kind of metaphysical commitments we might be making when considering it.

There are a few interconnected debates explicitly regarding the status of the future, and many others that are associated with it or have implications for it. This thesis will explore the debate regarding the *openness* of the future. An 'open future' is often vaguely described, but generally openness of the future refers to any sense in which some aspect of the future — be it its existence, contents, laws, etc. — is not fixed.

One of my tasks in this project is to provide a more lucid definition of the open future, using a four-part taxonomy. The second is to argue that when discussing the openness of the future, we should consider the view holistically using such a taxonomy. This is because taking a stance on the nature of one of these aspects of openness has an effect on the plausibility of combining it with certain philosophical positions associated with other aspects. Thus, much of the thesis will be looking towards these combinations both to show why considering the four-part taxonomy is important, but also showing which combinations are more and less plausible.

To create such a taxonomy, we firstly need to consider exactly what 'open future' means, and what assumptions we are making in discussing it. It is helpful here to consider ways the future might be closed. I suggest that the future might be closed in the following ways (at least):

- that the future already *exists*,
- that it is *determined* as to what will happen,
- that we have *knowledge* of what will happen,
- and that statements regarding the future have *truth* values.

I will explain what these mean in the following section. However, in touching on existence, determination, knowledge, and truth, we touch on ontology, laws of nature and necessitation, epistemology, and semantics respectively. Thus, there are four separate senses of openness and closure I will consider[1]: ontological, nomic, semantic, and epistemological (the latter two are considered together due to the nature of the connection between truth and knowledge for openness). In the definitions below I will explain what it is for the future to be closed in the different senses that I examine, and frame openness as the denial of different elements of this claim. To be open in the strongest sense, then, would be to deny closure in every relevant element.

[1] I acknowledge that the counterfactual dependence view of Lewis (1982) may provide another dimension of openness that might not fit into these four categories, and I hope to explore this in future work.

I. Senses of Openness and Closure

i. Ontological

In short, to say that the world is ontologically closed is to say that a single future exists. The most widely-held view that claims that the future exists is the ontological position of eternalism (see Mellor 1998, Sider 2001). Put simply, this is the view that all things that exist do so for all times t1,t2,…tn. For the eternalist, at the time of the dinosaurs, you and I exist. Similarly, at the current time future humans and the destruction of our planet exist. Everything that has, is, and will be, exits simpliciter, and there is no privilege between any of these times: the present exists just as much as the children born 50 years in the future do. However, there is another variety of eternalism that is ontologically open: the branching eternalist. This position claims that more than one future exists, and these future branches are ontologically on a par.

On the other side of the ontological divide there are those who would deny the closure of the future by claiming that the future does not exist. There are two well known varieties of this ontologically open view: presentism and growing block/ growing universe theory. Presentism, prominently held by Markosian (2004), Crisp (2007), and Keller (2004), is essentially the view that only the present exists; the past and the future do not. On the other hand, the growing block theory (see Broad 1923, Tooley 1997, Forbes and Briggs 2012) claims that both the past and the present exist.

ii. Nomic

To say that the future is nomically closed is to say that the contents of the future and their configurations are determined. This is to say that there is exactly one way things could turn out that is necessitated by the laws of nature given the world's state at time t.

Alternatively, the future might be nomically open. This consists in the denial of determinism, meaning that there are more than one set of world-states compatible with both the laws of nature and the world's state at time t. One motivation for this view is indeterminacy at the quantum level: certain interpretations of quantum mechanics such as the Copenhagen, Objective Collapse, and QBism interpretations are indeterministic in nature.

It is also important to note the difference between a state being determined and determinate: the former simply means that a certain event was necessitated by the laws of nature and the world's state at time t, while the latter means that such an event has a determinate and fixed truth value (i.e. is semantically closed).

These are related but distinct: for example, the world might be indeterministic (more than one set of states are compatible with the laws of nature and the world's state at time t), while each of these states had a determinate truth value.

iii. Semantic and Epistemological

For the purposes of this paper, to say that the world is semantically closed means that every proposition has some determinate truth value for all times. On the other hand, for the future to be epistemically closed is for it to be possible for the current scientific community — with their current scientific understanding and computational power — to have knowledge of *all* future states, and to be epistemically open is to deny this. These are treated together because they help to elucidate each other: the relationship between whether the current scientific community can know about a future state depends on whether there are truths about it.

However, it is important to note that though there is an entailment from semantic openness to epistemological openness and epistemological closure to semantic closure, there is not an entailment from semantic closure to epistemological closure, nor from epistemological openness to semantic openness. This is because it is possible for a proposition about the future to have a determinate truth value that the current scientific community does not know, while it is impossible for the current scientific community to know the truth of all future propositions if any of them have undetermined truth values. Thus, though I treat these two senses of closure in the same section, I maintain that there are important differences between the two.

II. Compatibility of the Senses of Openness and Closure

The second consideration regarding the *compatibility* of the views is that of treating a combination of views holistically as opposed to treating them as an aggregate of independent components. That is, I argue that we should make greater effort to consider the combinations holistically rather than one by one.

For example, I argue that we should evaluate (single-future Eternalism, Best System Analysis (BSA), Determinate truth values) as one view, rather than considering each component separately and then attempting to subsequently combine these, i.e. (single-future Eternalism) + (BSA) + (Determinate truth values) without considering each component's unique impact on the others. The main reason for this is that, without the other parts, each view generally doesn't have much to say. For example, single-future Eternalism is a very bare theory. All it says (roughly) is that one set of past and future times exist. An account of the openness of the future and/or past isn't complete without filling in the gaps of one's nomic and semantic commitments.

To continue the example of single-future Eternalism, two different views of lawhood might have very different impacts on what the view has to say about the world. For example, on the one hand Humean BSA tells us that the laws of nature are those regularities in local matters of fact that result in the strongest and simplest system of regularities to explain the world.

On the other hand, Necessitarianism tells us that the laws of nature are necessary relationships between certain universals. Necessitarianism has an ontological commitment to universals, while Humean BSA need not have this commitment: thus, the two views might have very different resulting ontologies. A discussion of the ontological commitments of eternalism simply wouldn't be complete without inclusions of its interactions with such other theories.

We must look not only to the merits of each individual view but how they play together. Without doing this, we might end up with an overall view that contains unappealing caveats and unnecessary complexity, or even contradictions.

Thirdly, I propose that one way to tease out the nuances in the compatibility of the views is to consider not only what they say about the future, but about the past. In this way we can see the implications for a whole potential view's ontology, metaphysics, and semantics, not just focussing on one part (the future). For example, we might have a metaphysics that tells us that the past and future are not relevantly symmetrical, and on ontology that tells us that they are. In the case of a mismatch, it is important to be able to explain and justify the differences between views.

This approach will allow me to defend the following claims, with the corresponding brackets indicating where defences can be found:

1. Nomic closure entails semantic closure (4.i)
2. Ontological closure entails semantic closure (4.i)
3. The BSA needs either ontological or semantic closure of both the past and future, or a branching eternalism, to provide the supervenience base for laws and to prevent the possibility of them changing over time (2.V.i, 4.i, and 4.vi)
4. Semantic closure is possible without either of the other types of closure (4.v)
5. There are many ways one can support a temporal asymmetry: through an asymmetry in ontological, nomic, or semantic closure (2.IV, 2.V, 4)
6. The only viable ontological asymmetry is GBT (1.II.iii, 2.V.i)
7. We cannot have nomic asymmetry (2.V)
8. We can have semantic asymmetry, but this is constrained by (1) and (2) (3.V, 4.i)
9. We can have a physical asymmetry (needs another kind of closure to justify it, e.g. ontological or semantic asymmetry) (2.IV)
10. We can have an epistemological asymmetry (needs semantic asymmetry) (3.II)
11. We can have an asymmetry of information (e.g. contained in records) (needs e.g. ontological asymmetry) (3.IV, 4.ii, 4.i)
12. We can have an asymmetry of influence (might require indeterminism plus semantic or ontological asymmetry) (4.ii, 4.vi)

I will approach this investigation using the following method: I will first take the ontological views of eternalism, growing block theory, and presentism and discuss potential challenges for the views, such as questions about dynamism and their fit with science, especially with the Special Theory of Relativity. At this stage I will for the most part only be able to raise and articulate these issues — in order to fully answer them, I will need to discuss the nomic and semantic commitments they might be paired with.

Next, I will take what I call the nomic views related to the open future — Humean Best System Analysis, Universalism, Primitivism, and Powers — and explore their implications for openness and closure of the past and future. Having discussed the ontological views in the previous chapter, I will explore the implications of the combinations of the nomic views with the ontological views, thus beginning to build a richer picture of openness.

Following this, I will take the semantic views of the acceptance or denial of bivalance and discuss the prima facie implications for each on openness and survey

the related literature. I will now take the ontological-nomic combinations of the previous chapter and explore what (if any) difference accepting each semantic view would make for them.

Finally, I will touch on the merits of each of the views with respect to other external factors such as fit with our best science, epistemology, and phenomenology. The primary aim of the project will be exploring the *combinations* of views and I will evaluate the compatibility of the views using the most charitable senses of the individual views. Instead of treating the views in great detail one by one with respect to topics like fit with experience and fit with science, I want to do more so for the combinations. This will hopefully reinforce the comparative focus of the project and not have the 'take-home message' be claims about individual views (for example that one ontological view is incompatible with special relativity).

III. Other Considerations

Finally, it is important to note that there are certain aspects of the philosophy of time that I will not be engaging with in detail in this project. There are certain considerations that despite being important and interesting questions do not tell us anything about openness itself but rather whether we should prefer one theory to another. The most prominent example of this is the debate regarding the passage of time. There are two components to this debate: what phenomenology tells us about how time passes, and whether this is an objective feature of the world or a merely psychological phenomenon.

However, an answer to either or both of these questions will have no *direct* impact on the questions that I want to answer. Knowing whether time really 'passes' does not affect the contents of the future nor the laws regarding them. However, it might be indirectly relevant, for example if time does really 'pass' this might gives us a reason to prefer one theory component over another, for example presentism or the growing block theory over eternalism, which is considered to be less amenable to the concept of passage.

One way that it could impact the debate is whether passage itself exists, and should thus be part of our ontology or metaphysics. However, this would not have a significant impact on ontological openness since for each view the existence of passage would be limited to the times that exist. It would not have a significant impact on nomic openness either, since passage would be concerned with the *process* by which the future comes into being, not about the nature of its contents and whether they are determined.

Since passage is a further question to openness, the literature on this topic is so great that it would be beyond the scope of this project to tackle it for such a small return. I instead refer the reader to the accounts of Price (2009), Prosser (2013), Baron (2017), and Markosian (1993). This may allow the reader to come to a conclusion about passage, which may be a reason to prefer one ontological or metaphysical theory over another. Given such a preference or a commitment, some views about openness will be ruled out.

I have a similar attitude toward the 3D/4D debate (see Sider 2001) and the related A/B theory debate (see Mellor 1998, and Dyke 2002) with respect to this project: they might be informative in terms of preferring a certain ontological theory, but they don't directly have anything to say about openness.

For example, if one takes the 3D approach to identity of an object over time they are *likely* to be a presentist. However, it is perfectly possible to be an eternalist on this view. It is important to note that a Presentist cannot hold the 4D view, but this does not affect my point, since a Growing Block theorist who holds ontological openness can take either the 3D or 4D approach. Thus, I think this is a consideration in metaphysics more generally but not a topic of openness in itself.

Similarly, the A/B theory debate — roughly the debate on whether tense is a property of events or merely a relation between them (should I rather say tense is a real part of the world?) — might provide a reason to prefer one ontological theory over another, but does not entail choosing one over the other. For example, many associate the A theory with 'dynamic' views such as Presentism or the Growing Block Theory, but it may be possible to be an Eternalist and believe that there are tensed properties of pastness, presentness, and futurity. I assess the plausibility of such a view — the Moving Spotlight — in the next chapter (see Deasy 2015, Cameron 2015) in light of McTaggart's (1908) challenge to its coherence.

I will also mention the A/B theory debate in the discussion of semantics (Chapter 3), since it concerns properties and relations it may have an impact on the truth conditions of propositions regarding the past, present, and future in conjunction with certain ontological and metaphysical views. Thus, when I address any of these debates, I raise them as considerations or objections to certain theories of openness.

With this in mind, in the next three chapters I will explore each element that contributes to a total view of openness, building up the views chapter by chapter. I begin with ontology in chapter one, then examine views of lawhood and other nomic considerations in chapter two. Having already discussed the ontological views, I will then note the interactions between the nomic and ontological views. I will continue this pattern in chapter three, where I will address the semantic and epistemic considerations, and evaluate all of the combinations in chapter four.

CHAPTER ONE
ONTOLOGICAL OPENNESS AND CLOSURE

When considering whether the past and future are open or closed, one of the important questions we must consider is 'do the past and future exist?'. When we discuss existence in every day life, we are usually speaking within the domain of empirically informed science — for example, we might ask whether a certain type of particle or field exists based on inference from relevant experiments, or whether an observable phenomenon postulated by a theory exists. These are things that we can observe, test, and confirm.

However, both in every day life and academic fields such as theoretical physics and philosophy we also discuss the existence of entities and concepts for which this type of empirical analysis is not *directly* applicable or does not yield conclusive results. Some examples in philosophy are natural kinds and categories in nature, numbers, non-natural properties such as moral and evaluative properties.

It is meaningful to ask whether those things exist, though we might not be able to determine an answer using only the methods we do for science. However, it is important to note that this is not to say that empirical data and experiment cannot and do not have an impact on determining whether these things exist or what kind of natures they have.

The existence of the past and future falls in this category — it cannot be determined purely with empirical data. However, some of the important arguments in the literature on the ontology of time are *based* on the findings of scientific enquiry; for example an argument from the findings of the theory of Relativity will be discussed in this chapter. The difference is that the question of the existence of the past and future can't be completely *settled* by the empirical evidence and analysis alone: it may for example be underdetermined by the data, meaning that there are many theories of the ontology of time that are consistent with this information.

It is important to note how I understand ontological closure of the future as existence the of a single future, and ontological closure of the past as the existence of a single past. However, this is not the only way the future might exist: more than one future may exist. Whether these futures exist on a par metaphysically (e.g. many branching views of time) or not (for example, for a Thin Red Line view (see p59). These views would count as ontologically open on my taxonomy, since it is open at world state t which of these branches some agent A will find themselves on. Thus, there is more than one way for the future to be ontologically open: either there is more than one future, or the future does not exist. For further discussion of this possibility, see 2.V.i and 2.V.ii.

There are three main positions in the ontology of time, each representing differing levels of the sort of openness I want to discuss. I present them from most to least open: firstly, Presentism is the view that only the present exists; the past and future do not. Secondly, the Growing Block theory is the view that the past and the present exist, but the future does not. Lastly, Eternalism is the view that the past, present, and future exist on an ontological par.

Though I will touch on the independent viability of each position and special issues that face them, the primary goal of the chapter is to draw out their possible implications for the openness of the past and future in such a way that I will be able to investigate their interactions with the other senses of openness and closure that I investigate in this project.

In section II, I will explore what each ontological theory tells us about the physical world and our experience of it. In doing so, I will expand on the brief descriptions of presentism, the growing block theory, and eternalism given above, identifying some philosophical considerations for their viability that might impact their ability to be paired with other nomic and semantic theories to form a theory of the openness or closure of the future and past. Following this in section III I will explore their interactions with physical theories which will also have an impact both on their viability and their potential interactions with other relevant theories.

However, before getting into the details of the disagreements between the views and their implications, it is important to note that it is debated whether there is even a substantive disagreement between presentism and eternalism in the first place. This argument is based on the understanding of 'exists' that the presentist and eternalist use. In light of this, I will briefly explore the most concerning of these arguments in order to clear the way for my discussion of the way each of the ontological theories affects our best theory of the openness of the past and future. In doing so I can claim that my findings of the comparisons are substantive.

I. Clearing the way for a substantive disagreement between views

The issue of substantivity of the temporal ontology debate is discussed in detail by Stoneham (2009), who explains the problem in the following way[2]:

'the appearance of disagreement [between the presentist and eternalist] can be made to vanish very quickly. To see this consider the following statement of presentism:

(P1) What there is only includes what exists now.

This sentence of English is straightforwardly ambiguous between:

(P2) What there is now only includes what exists now.

(P3) What there is, was and will be only includes what exists now.

Taken in their normal senses, (P2) is analytic and (P3) is an uncontroversial contingent falsehood. The problem is that the English verbs 'to exist' and 'to be' must always be tensed: we cannot say that something exists without saying more specifically that it does, has or will exist.' If understood as P2 or P3, Presentism is trivial or else false.

Miller (2013) explains why this problem occurs by pointing out because P2 and P3 are *tensed claims,* thus we must 'relativise the claim to some particular domain', whether this is spatial or temporal. If we do not do this, our claim will be insufficiently specific to have a substantive meaning. For example, for the term 'exists now', the truth of the claim depends on when it is uttered. Thus, it must be relativised to a time and place, even if this is implicit or assumed.

However, tense is still ambiguous, as pointed out in P2 and P3. For example, someone claiming that dinosaurs exist might either be taken to be making an *eternalist* claim about the total sum of facts including the past and our records of it, or else they would be taken as a *presentist* meaning 'exist' as restricted temporally to the moment they uttered the claim, and probably having a penchant for conspiracy theories.

Following this, if claims about past or future events are *restricted* to the present domain one, the presentist-eternalist debate to be insubstantial. In other words, the

[2] For alternative formulations this issue, see Noonan (2018) and Sakon (2015).

presentist and the eternalist both agree that dinosaurs do not exist — they agree the conspiracy theorist has made a false claim.

On the other hand, if they are quantifying over an *unrestricted* temporal domain, the disagreement becomes apparent. The presentist argues that when one makes the claim 'dinosaurs exist' they must be a conspiracy theorist, because there is nothing to quantify over but the present. The eternalist disagrees, claiming that they can use the first sense of exists because the unrestricted temporal domain allows them to quantify over the past.

How do we make sure both parties are quantifying over the unrestricted temporal domain? Stoneham argues that it is not enough to attempt to create a *tenseless* reading of 'exists', such as modification of the eternalist's sense of 'exist' as the eternalist does in the dinosaur case (i.e. using 'existed' or 'will exist', plus the context of utterance). This is because it collapses into a disjunction of tenses present in (P3) — 'exists' means 'existed, exists, or will exist'. As we have seen, (P3) fails to articulate a substantive tenseless reading.

Stoneham claims that in order to avoid this and articulate a substantive debate that 'we must introduce a new verb, 'to exist*', to express belonging to our most fundamental ontological category, the extension of which is the subject matter of ontological debate.' The debate over the status of past, present, and future events should be framed in terms of their existence*, not their existence.

The confusion begins when we conflate these two things, and while existence is important, existence* will be the core topic of this chapter. However, though I agree with the sentiment that these two things need to be distinguished, using a different verb entirely seems somewhat unnecessary, since the difference between these two notions is simply the domain of quantification. Thus, it is sufficient to simply make plain the domain of quantification, rather than introducing a new verb.

Since it is the relevant sense here — the sense necessary to have a substantive debate — I will proceed with the assumption of an unrestricted domain of quantification (Stoneham's exist*) and will explicitly point out when I am using a restricted domain version of existence.

A further motivation for using an unrestricted sense of existence comes when we consider the impact of our best physical theories on how we should view the world. The Special Theory of Relativity (which I discuss in section III) gives us a tool for conceptualising and representing such an unrestricted temporal domain: spacetime as represented on a Minkowski diagram. Such a diagram represents events over time such that one can specify what exists from this perspective. The presentist and an eternalist can point at the worldline of a dinosaur on such a diagram and disagree about its existence.

When evaluating this objection and replies, I think it is also important to consider a remark made by Dorato (2006): 'claiming that the *origin* of, or the reason for assuming, the semantic difference between present tense and future tense propositions is ontological is of course a mere *petitio principii*, since we want to know what such an ontic difference amounts to."

This shows us two things: firstly, it tells us that the interaction between ontology and semantics of time is significant and non-obvious. There seems to be an important relationship between the two, whether this is a relationship of grounding, entailment, or something else. This important question is one I will tackle in this essay, especially in chapters 3 and 4.

Secondly, it warns us that conflations or unfounded reduction between senses of openness and closure can be dangerous when trying to define a sense of openness and closure. It highlights that we must be cautious when proceeding, and keep in mind the tools we use for explanation.

This is a case of what I argued in the introduction: it doesn't mean much to say that you're an eternalist if in being one you could have two different semantic views that each give contradicting results about the nature of openness.

Now we have established that there is a substantive debate between the two parties, and so can move on to exploring the ontological theories and their relative merits and short-fallings. The function of this chapter is primarily to introduce the three key ontological positions with a view to making it clear what each would contribute to a holistically considered theory of openness and closure.

In the remainder of the chapter, I want to address the following questions:

1. What does each position tell us about what the world is like?
2. Are there any prima facie problems with each position?
3. How do they combine with our best physical theories of the world?

In doing so, I hope to provide an understanding of what each ontological theory can bring to a position regarding the openness and closure of the past and future.

II. The Three Theories

In this section I will introduce and discuss the three main ontological views regarding time, eternalism, presentism, and the growing block theory. I will answer questions 1 and 2 by investigating what each tells us about the world, and briefly discuss some of the issues that they face. The aim of this is not to to argue for any view over the other, but to introduce the views and to open up potential positive and negative contributions they might bring to a complete view of the openness and closure of the past and future when combined with other views.

There are two key philosophical considerations I will discuss. Firstly, if the present moment is ontologically privileged, and secondly if a theory can accurately describe events and processes with duration.There is a third important consideration regarding whether a theory can substantiate truth claims regarding past and future events and objects, but I will address this in detail in chapter three and so will only touch on it in this chapter.

i. Eternalism

Eternalism tells us that, in the most unrestricted sense, all events in the past, present, and future exist. There is no ontological privilege of one time over another — in other words, 500BCE is just as real as the time at which you are reading this paper, and that in turn is just as real as some moment 200 years in the future.

Because there is no ontological privilege between times this might lead eternalists to claim that there is no privileged present moment. An eternalist might claim that the terms 'now' and 'present' have a purely *indexical* function related to the speaker rather than telling us something about the world. On this view, when someone utters such sentences as 'Take action now!' or 'I'm trying to live in the present', they aren't picking out a feature of reality. They aren't trying to find a special time called 'the present' to

live in. Instead, they are referring to the time at which they are speaking. This is akin to spatial indexicals such as 'here': 'here' does not pick out a privileged feature of reality, it merely conveys the spatial position in which the speaker is situated.

However, this is not entailed by eternalism. The eternalist can — just as the presentist does — define some time-slice, point, Cauchy surface, etc. as the present and attempt to justify that choice (see section IV for examples). The difference is that while the presentist claims that this is all that exists, the eternalist does not.

In fact, there is a metaphysical view — the 'moving spotlight' (see Deasy (2015), Skow (2009), and Cameron (2015) for discussion) — which does combine an objective present moment with an eternalist ontology. On this view, there is an objective present moment that moves along the 'static' eternalist universe. The spotlight metaphorically 'illuminates' a different part of the eternalist universe at every moment, and this part is metaphysically privileged.

However, there is an important element of this view that strays directly from the discussion of ontology: the inclusion of the discussion of the 'flow' of time. I submit that this is not one of the ways in which an *ontological* position can differ greatly in what it says about the openness of the future depending on which other views it is paired with. This is for a simple reason: all of the views can be formulated both with and without accepting a flow of time.

In addition, for this reason I will not be including a detailed discussion of the flow of time in this project, as I explained in the introduction. There are many things that tell us about the ontological openness and closure of the past and future, but whether there is dynamism or 'flow' of time is not (directly) included. The consideration of flow might give us evidence about the *legitimacy* or *attractiveness* of an ontological theory, not the relevant *content* of that theory. Flow itself does not tell us anything relevant about the relevant temporal ontology regarding openness and closure. It is an interesting question, but considering it will not lead us any closer to the answers we are looking for.

Having established that there are options for a privileged present in the eternalist framework, we can ask how the eternalist deals with descriptions over time. Consider a process that occurs over a significant amount of time: for example corrosion, homeostasis, or entropic increase. It is essential to these processes that their identity is considered as a whole: there is nowhere near enough information to define or characterise them from a single time-slice. Thus, eternalism can give a straightforwardly complete characterisation of such processes.

In sum, eternalism is the view that the future exists. It does not tell us whether or not there is a privileged present (the theory is compatible with there both being and not being one), and it can very straightforwardly characterise processes over time.

ii. Presentism

Presentism is the view that only events and objects in the present exist. For the presentist, the most unrestricted domain of quantification includes only the present. Thus, the presentist necessarily has a privileged present. Another common feature attributed to presentism is what Miller (2013) calls the 'Dynamical Thesis': 'The present moves: which moment is the present moment changes'. However, the question then arises of what the present is supposed to change with respect to if it is the only

thing that exists: that is, if change is something like difference over time then it is unclear how to define change in a presentist framework.

On the one hand it seems that presentism has the potential to offer us an explanation of the change and dynamism we experience (through things going out of and coming into existence), but on the other hand one might argue to change over time is to admit the existence of other times.

Another question for the presentist is how to connect their ontology with facts about a process happening to something over time. For such processes, only a part of it will be contained in the presentist's ontology, so how can they make true claims about the process as a whole? For an eternalist or the GBT this is more straightforward, as one has the entire history of the process in their ontology.

However, this does not mean that the presentist cannot theoretically model spacetime like an eternalist, they are just not committed to their ontology. For example, the presentist might use a spacetime diagram that represents times other than the present, and try to ground facts about those other times in alternative ways.

One option is to posit that facts about the process can all be found in the present. Alternatively one could claim that facts about the process can be derived from the current world-state plus laws of nature, which will be discussed in chapter 2. However, there is a consideration regarding what the present is like that might affect the plausibility of these responses if you hold a process-based ontology.

If the 'thickness' of the present tends to zero, one might argue that it is difficult to define properties where change over time plays an essential role; Sider (2001) has a version of this argument that one's instantaneous state of motion is determined by positions at various times, and so must be grounded in facts involving times other than the present. As a result it may be problematic to define certain quantities such as velocity as a presentist, since this involves by definition more than one time. However, having an ontology that centres processes such that this would be a key issue is a position that is not widely held, thus is not a source of concern for the majority of readers.

To surmise, presentism is the view that the past and future do not exist, only the present. Thus, by supposition, the present is privileged. The question of characterising processes over time is more difficult than for eternalism, but there are views that will be discussed in chapter 2 that give alternative ways of grounding truth claims about non-present processes.

iii. The Growing Block Theory

The Growing Block Theory (GBT) states that both events in the past and present exist, but not the future. As with the presentist, the GBT believes that 'the present' picks out an irreducibly tensed feature of the world. However, the GBT defines the present as the *edge* of the growing block of spacetime.

As Button (2006) points out, "Is this moment present?' is a serious question only for theories which, like no-futurism [Growing Block Theory], hold that there are both present and non-present moments. This is because of the concern raised by Bourne (2002: 360) and Braddon-Mitchell (2004: 200) that today I am just as convinced yesterday that my time is present. How can we tell that we are not mistaken if we have

the same information if we were actually in the present as we would at a time before the present?'

Button claims the solution to this sort of problem requires tense; the solution is for the GBT to deny that any one moment is present in the untensed sense, as this would be straightforwardly false. To say something is true in the untensed sense is to say that this is true at *all times*, which contradicts the GBT's defining tenet that the present — the edge of existence — changes as time passes. Thus, we must use tense to formulate the view. As Button puts it, 'different answers must be given at different times to the question 'what *is [tensed]* real?''. Existence is non-symmetric for the GBT — the present is a time such that it *has* no relations to any future statements.

It is important to note that it is then a further question as to whether we are *correct* when we utter the tensed sentence 'this is the present'. Given 'the truth of all tokens of 'this moment *is* present' follows immediately from the non-symmetry of 'real-as-of'', showing that this non-symmetry is the case for any given case is a further question. However, what is shown is that the GBT thesis is consistent and plausible.

A related issue is raised by Merricks (2006), who (quoting the quintessential growing blocker, C.D. Broad) emphasises that nothing intrinsic — only relational — changes when something goes from being present to past. Thus, it is unclear what the truth value of a statement like 'I am sitting here at the present time' has. This mirrors the further question of correctness that comes after Button's argument for the consistency of the GBT.

On what Merricks calls the untensed view, there is one time t at which what I say is true, and every time after this I am false. This is because on the untensed view we are taking a sort of external or absolute perspective on time. On the tensed view, my utterance is about the subjective present - the present relative to me - and so is true. Merricks comments that 'such thoughts can be true even though I am not on the edge of being'. This is the kind of view, presumably, that he would take Button to be expressing.

Merricks claims that the GBT must have *both* the objective and subjective present. Merricks argues that the conflation of the two is what might make the theory seem 'natural', when in reality this is far from the truth. We might know all the facts about the subjective present and past, for example, but not know whether the objective present is the subjective present, 30 minutes after, or a million years after that.

He argues that recognising this removes many of the intuitive appeals of the GBT, especially the idea that the non-existence of the future implies that there is no fact of the matter about it. Either we distinguish the objective and subjective present and admit that it is unlikely we are in the objective present, or we identify the objective and subjective present and face the untensed view of time that has every past utterance of 'this time is present' become false.

I think this comes from a very strange 'looping' sort of view of time, which sees every moment of time 'playing' again and again as the growing block extends. However, this is not what the growing block tells us. In the very fact of stipulating yourself being located at t, t is present and the future beyond t doesn't exist. You are in doing so locating yourself in a perspective where you are at the edge of the block, the event 'happening' for the first and only time.

Another consideration regarding the GBT is its intersection with our best physical theories. For example, the relationship of the GBT to the theory of relativity is unclear, and will be examined later in this chapter. Further, a growing number of physicists are adopting a growing block ontology due to their espousal of causal set

theory, most famously Fay Dowker (2020) (see also Wuthrich and Callender (2017), and Sorkin (2007)).

In sum, the growing block theory is the view that the past exists but the future does not. The present is privileged since it is on the edge of being; it is the point which has relations with present times but not future times. Characterising processes over time is easier than for presentism, since the growing block theorist has all past times in their ontology.

III. Interactions with physical theories: Relativity

One issue that people have raised (e.g. Sider (2001), Saunders (2002)) — especially regarding presentism — is how ontological theories interact with the findings of modern physics regarding spacetime, especially the Special Theory of Relativity (STR). As Callender (2017) points out, though much philosophical work in this area focusses on the STR, it is important to remember that it is one solution to the general theory of relativity, so we should consider the theory as a whole (see p42-43).

One reason that philosophers may focus on STR rather than the General Theory of Relativity (GTR) is firstly because they consider it sufficient to prove the point that they are attempting to make, and secondly because over not-too-large regions with not-too-strong gravitational influences space-time is approximately modelled by STR. For example, many discussions in the area ask the question of whether presentism is compatible with relativity. The logic seems to go that if one can show it is incompatible with one solution of GTR (STR), one has shown it is incompatible with GTR.

However, there are further considerations that may allow one to defend presentism via features of GTR. One such consideration is discussed in Bourne (2004): that the expansion of the universe can give an 'absolute time'.

The question of whether the Special Theory of Relativity (STR) is incompatible with an ontological theory is difficult to tackle for many reasons, the most pressing being that one must understand the relevant physical and philosophical concepts to pose the question in the first place.

To that end, I assume the reader has little to no experience with STR. I will explain the concepts relevant to the compatibility question and use these terms to pose some challenges and responses in the relevant literature. I will also direct the reader to some further resources on the topic, since I am not able to go into much detail given the nature of my project. That is, I will give sufficient explanation to frame and answer the questions related to the openness and closure of the future.

The Special Theory of Relativity is a physical theory that explains the differences in the apparent motions of objects given different perspectives in space. It is one solution to the Einstein field equations, concerned with the *inertial reference frames*: perspectives in which the observer is experiencing a net force of 0. That is, the observer is either at rest or travelling at a constant velocity, with zero acceleration. If one did accelerate, one would boost oneself into a different reference frame. To understand the concept of a reference frame, we must explain some other concepts regarding the physical framework in which we are working.

The most fundamental of these to understand is *spacetime*. Within STR, space and time are part of one four-dimensional manifold, which we represent on a Minkowski

diagram. Though there are four dimensions of spacetime, some may be suppressed on a Minkowski diagram: for example only one that is spacelike (usually the x axis) and one that is timelike (usually the y axis) might be represented (e.g. figure 1, below left).

This is for two reasons: firstly, it would be impossible to represent all four dimensions on such a diagram. Secondly, though one could make a three dimensional diagram, this is rarely needed for calculations and can be unclear. However, a 3D diagram (such as figure 2, previous page right) may be useful for explanatory and illustrative purposes (i.e. the light cone structure of spacetime).

Such a diagram is that of figure 1 (previous page left). The mathematical structure used on a Minkowski diagram is called the Lorentz co-ordinate system, and can be used to calculate the geometrical relations between the trajectories of objects. These trajectories are representations of the motions of objects through spacetime, and are called *worldlines*.

One such representation of worldlines can be seen in figure 2. This figure represents the structure of Minkowski spacetime, and needs some explanation. For any point in space (here illustrated in the centre), there are both past and future *light cones*. Light cones are defined by the speed of light, which is the speed limit of the universe. This is significant because it means that this xalso defines the limit of causal propagation for this spacetime point; its worldline can only travel within this cone. Therefore, these cones define the limits of its past and future. If two events are within each others light cones, we say they are *timelike* separated, whereas if they are not we say there are *spacelike* separated.

i. STR tells us that there is no privileged reference frame

Using Minkowski diagrams, one can explain the difference between how O experiences both their own motion and the motion of O′, and conversely how O′ in their reference frame experiences those motions. Using figure 1, let us say that the reference frame of O is indicated by the orange axes, and the reference frame of O′ is indicated by the blue.

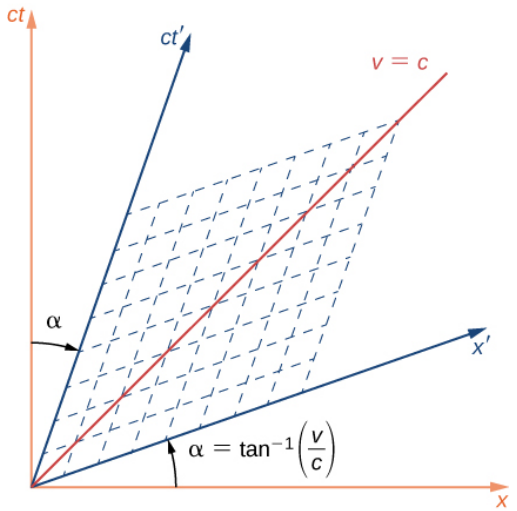


Figure 1
Ling, S. J., Sanny, J., Moebs, B., et al. (2020)

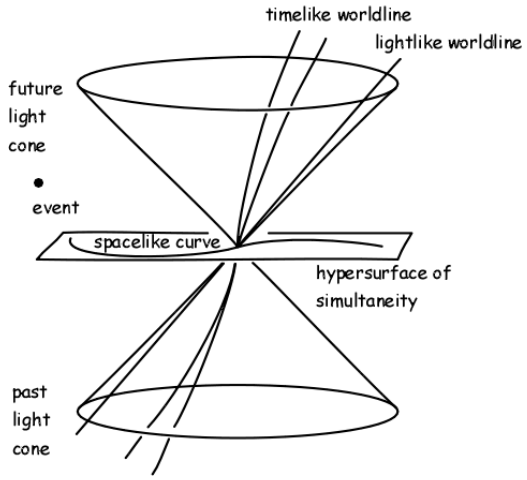


Figure 2
Norton, J. (2007)

Each positioning of the coordinate axes corresponds to the perspective of some inertially travelling object in spacetime (cf. Emery 2019). In other words, each inertial observer has their own reference frame. A core tenet of STR is that none of these reference frames is any more legitimate than another when it comes to giving us information about spacetime and its inertially moving objects. In other words: *STR tells us that no frame is privileged.*

White (1993) points out that choosing a reference frame is necessary to present a set of observational data in STR, but this does not mean that this frame is privileged, only that it is being used for practical purposes; any other choice of frame would give equally legitimate results. To see this, note that O experiences time — as we all do — passing at one second per second. O also experiences no force; since they are in an inertial reference frame by postulation, they are either travelling at constant speed or at rest. This can be easily seen in the fact that although someone seemingly at rest on Earth (phenomenologically, they are still), due to the constant velocity of the Earth, they are in fact moving at 30km/s with respect to the sun.

However, *the very same thing is true for O′* given they are both inertial reference frames. We could redraw the co-ordinate axes with the axes of O′ being in place of O, and it would be equally legitimate: regardless of the reference frame used, we will obtain the same empirical results. In fact, Lorentzian geometry gives us the resources to do just this, given certain special properties of spacetime.

In sum, STR tells us that no particular reference frame can give us any extra or better information about the inertial movement of objects in spacetime.

ii. Relativity of simultaneity: time dilation and length contraction

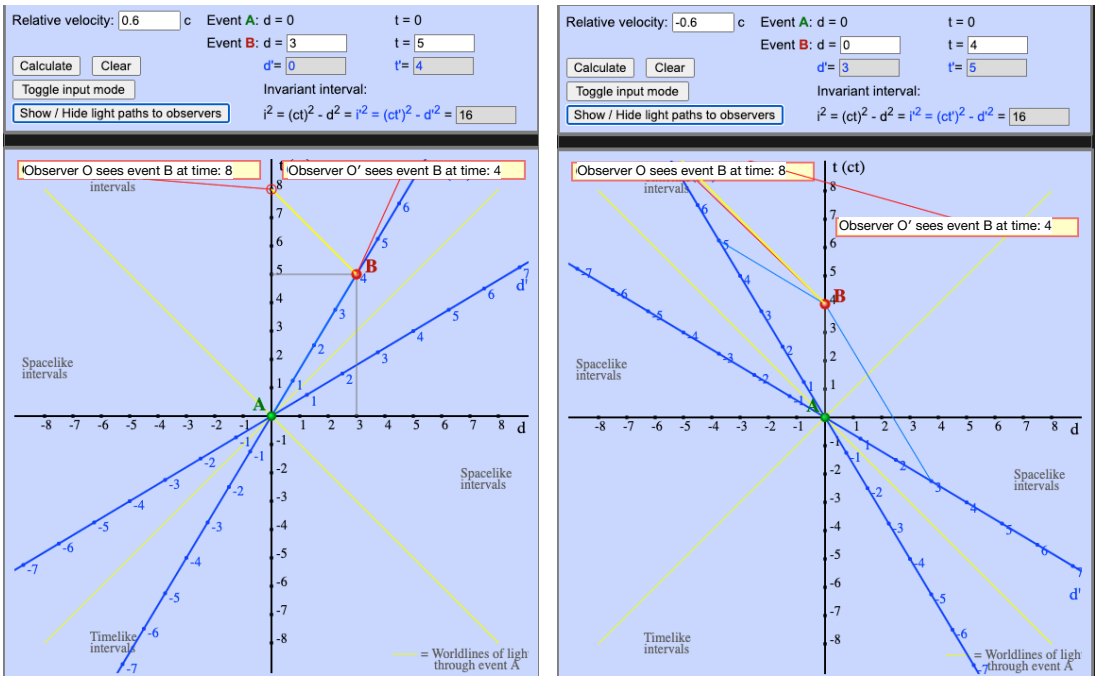
The special property of spacetime is this: the speed of light is the same in all reference frames (approximately $3x10^8$ m/s). As I mentioned in section (i), this speed is the maximum velocity possible in the universe, and thus defines the past and future light cone of a spacetime point.

How does this help us? It gives us something that is consistent in all reference frames, something that stays constant if we want to change *between* perspectives. This is why, if we want to see figure 1 from the perspective of O′, we cannot simply rotate the graph through $\alpha°$ anticlockwise to see the reference frame. If we did this, the worldline of light would be at $45\text{-}\alpha°$, when it must always be at 45°. Furthermore, the x axis of O′ would now be at $90\text{-}\alpha°$.

The first special property of Lorentzian geometry is that the angles between the worldlines of intertial objects remain constant between reference frames. For example, for both O and O′, the angle between their axes will always be α given they each remain in their respective reference frames (i.e. neither of them accelerate).

The second special property of Lorentzian geometry is that no matter the reference frame we choose, a certain measure called the spacetime interval is always the same. This can be calculated using the formula $I = \sqrt{(T^2 - X^2 - Y^2 - Z^2)}$, where T, X, Y, and Z represent the change in the co-ordinates in the four spacetime dimensions. The full explanation of the mechanics of this transformation will not be relevant here, but I point the reader to Maudlin (2012) for a helpful explanation.

The Lorentz geometry on spacetime diagrams allows us to perform *Lorentz transformations* between reference frames that satisfy these three facts and thus give us



Figures 3 (left), 4 (right) above, and 5 (below) created with animation by Kristian Evensen available at http://www.trell.org/div/minkowski.html. Figure 3 shows the reference frame of O, and Figure 4 shows the reference frame of O'. Event B here shows t=4 for O'. Figure 5 shows the reference frame of O'. Event B here shows t=4 for O.

accurate representations of the reference frames of inertially moving objects. Through performing such transformations, we can see a very strange phenomenon that STR predicts: time dilation and length contraction.

This is best illustrated by example: consider two observers O and O′. Let's posit a frame of reference — represented in the sapce-time diagram figure 3 — such that O is stationary and O′ is moving at a constant velocity of 3/5 the speed of light. The black axes represent the reference frame of O, and the blue axes represent the reference frame of O′. Since the interval must remain constant (i.e. $I_O = I_{O'}$), we can calculate exactly the times at with O and O′ perceive the same event.

The perceptions of events are calculated using light signals that act as clocks. A light signal is emitted at an event (in this case event B), and travels towards the worldlines of O and O′. The point at which this light signal intersects the

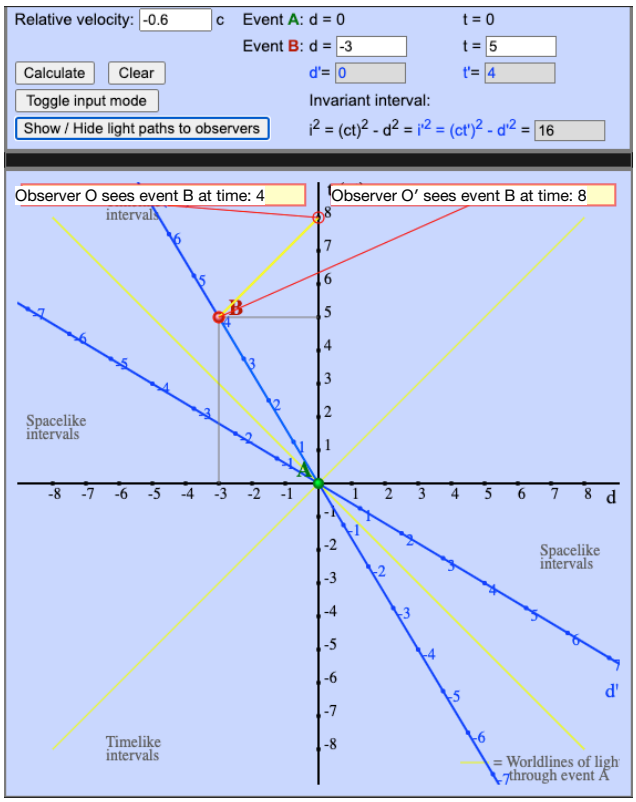


Figure 5

worldline is the point at which the observer will judge event B to have occurred.

Looking at figure 3 (above), O will judge B to occur at 8 units in the timelike direction. But this is not so for O′, who judges B to occur at 4 units in the timelike direction. This is all to say: whether an event is judged to be simultaneous is dependent on the reference frame. This is also shown in the reference frame of O′ in figure 4 after performing a Lorentz transformation.

Further, this discrepancy also shows that O perceives O′ to be moving *slower* than they in fact are. If we think about each unit in O's reference frame as an event, there will only be one event for every two units in the timelike direction O moves. Thus, it will appear as though time is passing twice as slowly for O′.

However, this does not mean that for O it appears that time is passing twice as quickly for O′ : in fact, when a Lorentz transformation is performed in order to privilege the reference frame of O′, the same phenomenon will occur: O′ perceives time moving slower for O. This can be seen in figure 5, where the reference frame of O′ is privileged (i.e. the black axes are of O′ and the blue axes are of O). We choose another event B' on the worldline of O, and we see that O′ judges that this event occurs at 8 units in the timelike direction while O judges it to be at 4.

Thus, O looks slow to O′ and O′ looks slow to O. Who is right? When we remember that no reference frame is privileged and so both are equally valid, we realise that *both* of them are right. This leads to one of the most important conclusions of STR: the relativity of simultaneity.

It is important to note here that this is a *subjective*, frame-dependent phenomena. It is often confused or conflated with another important conclusion of STR that is *objective* and frame independent: what is commonly referred to as the twin paradox.

iii. Twin 'Paradox'

The crucial difference between time dilation and the twin 'paradox' is that the latter involves a change in reference frame for an object, whereas the former does not. The word paradox is in scare quotes because it is important to emphasise that this is not a paradox at all, it is simply a feature of the spacetime made apparent by the mechanics of STR.

A case of this phenomenon is illustrated in figure 6 (next page), which is an extension of figure 3. We imagine that while O has a few reservations about space travel and decides to stay on Earth, O′ boards a rocket and leaves Earth at 3/5 the speed of light. O′ travels (in her reference frame) inertially for 4 years, eventually reaching a distance of 3 light years. Along this route, the twins send light signals every year to communicate with each other using light. O's signals are indicated by the red arrows, while those of O′ are indicated by the blue. Note that these are always at 45° to the axes, since they are worldlines of light acting as clocks.

Up to this point in the story (the 5 year mark in O's frame, the 4 year mark in O′'s frame), we can treat the case exactly as we did figures 3-5. The lines of simultaneity (indicated in grey) show the points on Liz's worldline which Beth judges to be simultaneous with parts of hers. as with O and O′, Liz and Beth perceive time moving slower for each other.

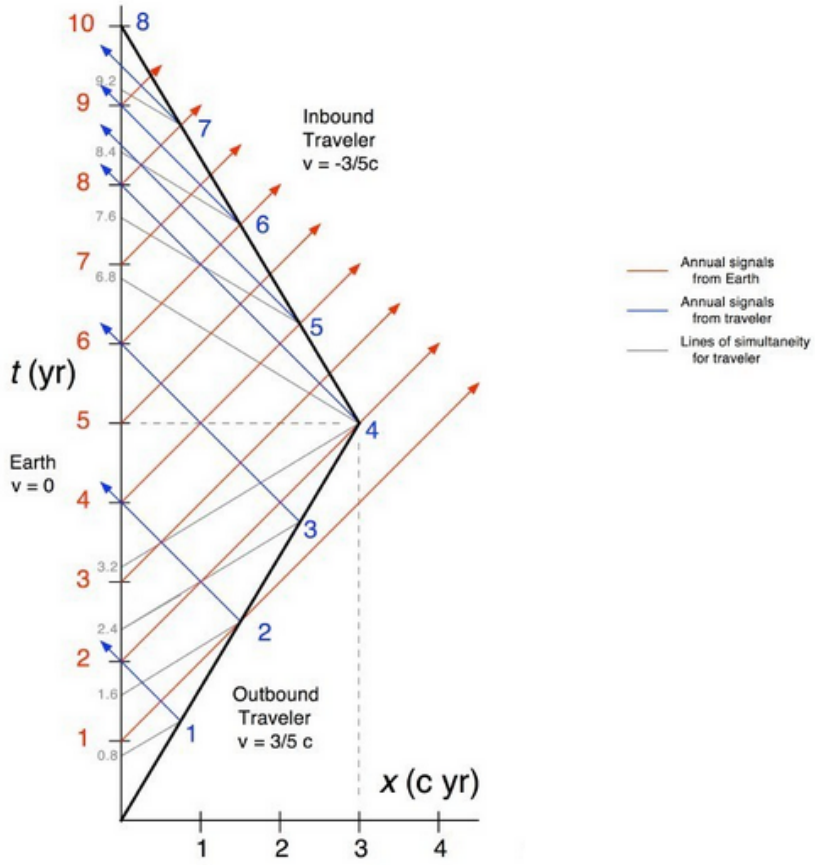


Figure 6.
Mallinckrodt, J. A. 'The *so-called* "Twin Paradox"'

However, a crucial difference occurs at O′'s fourth year: she boosts into a *different reference frame* and starts travelling 3/5 the speed of light back to Earth. The trajectories now become physically asymmetric.

As a result, phenomena become different and O's perception of O′ reverses: instead of perceiving O′ to be moving *slowly* relative to her, she now perceives O′ to be moving *faster* relative to her. This can be seen by looking at the light signals sent from O′ to O — in the first eight years O only receives four signals, while in the last two years she receives four (including contact on O′'s return; in the following this contact will be included as a light signal).

Two important differences should then be noted: firstly, for O this change occurs in the last two years, whereas for O′ the change in the apparent velocity of O changes at her four year mark. This can be seen in the fact that O′ receives eight light signals from O within the last four years equally spaced along her worldline. Secondly, whereas O receives eight total light signals from O′, O′ receives ten total light signals from O.

Thus, when the twins meet again O′ is two years younger than O; she has experienced two years fewer *proper time,* which is given by the spacetime Interval. Proper time differs from movement in a timelike direction because the first is frame independent and the second is frame dependent.

Remember that $I = \sqrt{(T^2 - X^2 - Y^2 - Z^2)}$. Since the result is frame independent, we will use values from Liz's frame. The reader can repeat this with Beth's values if they wish.

For O, $I_O = \sqrt{(10^2 - 0^2 - 0^2 - 0^2)}$, or 10.

For O′, we can do two calculations: $I_{O'1} = \sqrt{(5^2 - 3^2 - 0^2 - 0^2)} = 4$ and $I_{O'2} = \sqrt{(5^2 - (-3)^2 - 0^2 - 0^2)} = 4$. $I_{O'1} + I_{O'2} = 8$, a difference of 2 units from 10. Thus, O′ has aged less than O when they are reunited.

This shows us something important: that the proper time cannot be used as a measure of simultaneity. In other words, we cannot use it to determine which events are co-present, since though different amounts of proper time have passed for O and O′, they can causally interact with each other in a way indicative of co-presentness when they meet.

IV. Questions, Solutions, and Objections

We can ask whether STR gives us any conclusive answers regarding the questions posed at the beginning of the chapter. Firstly, is the present moment privileged, and secondly can a theory accurately describe events and processes with duration?

The answer to the second question is yes: all ontological views, even Presentism, can use the tool of a Minkowski diagram to represent processes that happen over time. However, the Presentist and the Growing Block Theorist, who both postulate an irreducibly tensed present, must justify the claims represented on the spacetime diagram differently. This relates to the answer to the first question, STR tells us that there is no privileged reference frame, and so anything that might be thought of as a present moment in a particular reference frame is no more valid than a present in any other. Indeed, the concept of presentness plays no role in STR. So what are the Presentist and the Growing Block Theorist to do? They must be able to point to a spacetime diagram and tell us where the present is. There are many ways one might attempt to do so, and the legitimacy of these will dictate the viability of the Presentist and the Growing Block positions:

Spacelike separation: Also called Elsewhere-ism or Bow-tie Presentism, this is the view that an observer is co-present with everything which has zero timelike separation from them. Thus, referring back to figure 2, the present consists of the bow-tie shaped region outside of the observer's light cones: the absolute elsewhere.

As Emery (2019) puts it, for any two spacelike separated events, there is no fact of the matter as to whether those events happen at the same time. Anything that is outside the light cone of O would be undefinable in these terms, so we would have to say they don't exist.

This view is difficult to motivate because presentism entails that only one moment of an object's worldline exists. This is incompatible with the spacelike separation view, as an object located in the absolute elsewhere could, as noted by Gilmore, Costa, and Calosi (2016), have its entire worldline within the present. This would mean for such an object there could be no relations of precedence within its existence, which is absurd.

This applies equally to the Growing Block, since the present is the edge of the block, and that which has no relation to future states but only past ones. On this definition, whole world-lines of objects might be located in the present at once.

Light cone presentism: this is the view that the present consists in the interval separation between two spacetime points being zero. For an observer, this is equivalent to the outer surface of their light cone. A motivation for this, expressed by Hinchliff (2000) is that light cone presentism accords with the idea that I am simultaneous with what I see.

However, holding this view leads to the unintuitive conclusion that there are some things we are co-present with that seem to be in our causal past. There are certain things that one can see that illustrate this well: we see long-dead stars because according to light cone presentism the entire career of a photon can be included in the present. It is hard to even conceptualise the idea that these things are both co-present with us and billions of years in the past. This applies equally to the Growing Block Theorist, and in fact may be even more problematic since they have past existent states to justify these claims of causal precedence.

Point Presentism: this is the view that there is only one privileged present point in spacetime. Thus, it is only possible for one observer (or one point of an observer!) to be present (for further discussion see Hinchliff 2000 and Stein 1991).

There are two obvious difficulties with this position. Firstly, the Point Presentist or Growing Block theorist who endorses this position faces a strange dilemma to justify the spacetime point that they claim is present or else be accused of arbitrariness. Secondly, they must either endorse extreme solipsism whereby only one part of themselves exists (or is present), or justify choosing some other spacetime point and denying their own existence (or presentness). This amounts to a reductio ad absurdum of the view, and I think we can safely disregard it.

Cauchy Surface-ism: a Cauchy surface is presented by Gilmore et al (2016) as roughly 'a three-dimensional spacelike region that spans the entire spatial extent of the universe' such that spacelike and timelike curves pass through it only once. According to the Cauchy Surface-ism view, the present moment consists in such a Cauchy surface, such that each distinct point on the surface is simultaneous with the next. Such a view does not contradict STR if it does not posit a privileged reference frame. However, there is a burden of proof on the Cauchy Surface theorist to justify which Cauchy surface is the present, or else be faced with empirical inadequacy. It is also unclear how black holes affect the plausibility of the present as a Cauchy surface (see Sengers (2017) and Romero and Pérez (2014) for discussion).

The takeaway from considering these approaches to defining the present with respect to STR is that it's an open question as to whether STR entails an eternalist ontology. There are live attempts to define such a present moment, the most plausible of these being Cauchy Surface-ism. Whether or not the reader is convinced of the plausibility of these attempts we have at least one *logically* possible conception of presentness compatible with STR, which is sufficient to claim that the ontology of the future is still an open question and that we can't rule out any of these ontologies.

In this chapter, I have introduced three key ontological views: presentism, eternalism, and the growing block theory. I have noted special considerations for each,

and have now begun to generate the framework with which I will combine these views with nomic and semantic positions. Bearing the questions and possible issues raised in this chapter in mind, in the next chapter I will combine these ontological views with the nomic views of Humeanism (specifically the best system analysis), universalism, primitivism, and powers.

CHAPTER TWO
NOMIC OPENNESS AND CLOSURE

In this chapter I will explore nomic openness through considering two key concepts: determinism and realism about lawhood. In the discussion of the first I will discuss the relevant types of necessity: logical and physical necessity.

Within physical necessity, I distinguish two important senses based on two different types of what I call 'natural facts', which are true propositions about the contents of the natural world, potentially including but not limited to objects, properties, and relations. Lawlike natural facts hold independently of the existence of specific objects and regardless of a particular world-state, while specific natural facts do not.

Following this, I will explore what openness and closure mean in this nomic sense I have outlined. I introduce nomic closure as determinism: a corollary of physical necessity. Determinism amounts to the claim that one set of successive states is compatible with the lawlike natural facts and the world's state at time t. I contrast this with the metaphysically stronger claim of fatalism, which will also be discussed in chapter three.

Discussion of the second key concept of realism about laws will be addressed by exploring different accounts of the laws of nature, since this way of articulating the natural facts that has a large impact on openness and closure. More specifically, realist theories of lawhood claim that there are a subset of the lawlike natural facts — the lawlike natural facts — that have special importance in explaining the natures of the contents of the world and how they relate to each other. To investigate this will explore the Humean, Necessitarian, Powers, and Antireductionist approaches to lawhood.

I will conclude the chapter using my discussion of ontological positions from the first chapter to combine with these nomic views, exploring of openness and closure of the future with respect to their combinations. An important part of this exploration will be consideration of the application of these views to the past direction and the justification that must be provided if one wishes to hold the opposite views of openness and closure with respect to the past and future.

In doing so I will discuss at some length the justifications for an asymmetry in time, with particular attention given to the relationship between entropic increase and the direction of time. This will then be applied to the discussion of openness and closure and a more complete picture formed.

I. Types of Necessity

To begin, it is important to point out the kinds of necessity that I will not be concerned with in this chapter, which are logical necessities.

There are certain states of affairs that are necessitated by universally applicable rules of logic: to take a simple example, if P&Q obtains, it is logically necessary that P obtains. Other logical necessities such as self-identity also fall under this category. I won't be specifically concerned with this type of necessity in this project, since the laws of logic are universally applicable in every possible world and so it would not impact any sense of openness and closure that there could be significant debate over.

Lastly, if something is *physically* necessary, there are no compatible possible worlds in which certain lawlike natural facts are other than they are. I use the term 'natural fact' to refer to any true proposition about the contents of the natural world, potentially including but not limited to objects, properties, and relations.

I use this term 'lawlike' in order to be reasonably neutral about the status of laws of nature; different accounts of the laws of nature will have different ideas about what makes a natural fact lawlike, but there is a sense in which they are aiming to define the same thing. For example, a necessitarian account of laws of nature might claim that laws are the necessary natural facts about the relationships between properties. On the other hand, the Humean regularity theorist might claim that laws are patterns in the actually existing natural facts. I will expand on these different accounts later in this chapter.

II. Lawlike and Specific Natural Facts

There are two types of natural facts, which I will call 'lawlike' and 'specific'. *Lawlike* natural facts are those which hold regardless of the existence of specific objects, and most importantly regardless of the world's state at time t. For example, it is a lawlike natural fact that nothing can travel faster than the speed of light. Given that the natural facts are as they are, there are no possible worlds — no matter the actual world-state — in which anything crosses the boundary from travelling below the speed of light to above the speed of light.

On the other hand, it is a *specific* natural fact that there are planets containing water. The world's state at time t and the lawlike natural facts (if they are deterministic) entail that there are planets containing water, but given a different world-state at t it is physically possible that there are no planets containing water (or planets at all, for that matter).

Lawlike natural facts can be interpreted in many ways, and it is possible that we might never — even in principle — be able to know their content if they exist. This is because our evidence for what these necessary natural facts are, which are simply the empirically accessible the natural facts that obtain in the actual world, underdetermine their content and form.

In this stance I align with Mumford (2002) when he says:

'Laws may variously be thought of as statements, empirically well-confirmed theories, fundamental universal truths, theoretical identities, relations between universals, or real essences of natural kinds. These theories may not be at odds: there may be all these things. A claim that one of these theories has successfully identified or characterized the class of laws looks very suspect, however.'

I agree with Mumford that there may be all these things, and it is not the purpose of this project to provide arguments for or against any of these positions. I only aim to explore the possible implications of different expressions of lawlike natural facts on the understanding of the openness and closure of the past and future. The following are some influential accounts of what these expressions might look like.

i. Relationships between universals are laws (Universalism): this is the view that there are laws of nature that are things that underlie the physically necessary natural facts. For example, a necessitarian view of lawhood like Armstrong's (e.g. 1983) tells us that there are certain laws that govern the relationships between properties. Other

notable proponents include Dretske (1977) and Tooley (1977). On this view, Newton's second law is a necessary relationship between force, mass, and acceleration. This makes it a physically necessary fact that all instances of Newton's Second Law are true. As such, the future is closed of physical necessity in the sense that all worlds are ruled out in which the lawlike relations fail to hold. Another example is the primitivist view, which understands laws as primitive facts (e.g. Maudlin 2007; see Dorato and Esfeld 2014 for discussion). Thus the laws would be a special subset of the natural facts, which then determine the specific natural facts.

ii. Best Systematisation of general regularities in natural facts are laws (Best System Analysis): a regularity account of lawhood such as the Humean Best System Analyses (held prominently by Lewis (e.g. 1983), Loewer (2012) and Beebee (2000)) might also hold that certain facts are physically necessary, if understood in the sense of being *consistent* with the laws of nature. For the Humean there are no necessitation relations weaker than that of logical necessity, so physical necessity can still be understood by the Humean, though this understanding is very different (and less strong) than that of the necessitarian. Unlike the necessitarian who views the laws as necessary natural facts, the Humean holds that the laws of nature are facts that supervene on the actual matters of fact in the world. To determine the laws of nature, the Humean takes all events and examines the patterns that occur between them. On a typical Humean analysis, 'patterns in local matters of fact' is the expression used to describe the basis of the laws, so they might take the view that natural facts are states of affairs, events, or something of that sort. On the Best System analysis, these patterns are then analysed according to how simple and strong an explanation they can provide as to how and why the events are as they are. The simplest and strongest systematisation of these facts will form the Best System, and these facts are the laws of nature.

iii. Laws are irreducible natural facts (Primitivism): on this view laws are not reducible to relations, patterns, nor dispositions, they are simply laws. Advocates of this position such as Maudlin, Carroll, and Lange claim that there is no advantage in taking the Humean or Universalist approaches; instead, one needs only nomic concepts to explain nomic phenomena and we should not attempt to ground or reduce it. Instead, a law should be treated as fundamental in our ontology, and cannot be explained in terms of nomic concepts such as counterfactuals.

iv. The nature of property dispositions are natural facts (Powers): on this view, held prominently by Mumford, Bird, Marmodoro, and Ellis, there are possible worlds that are ruled out because of the natural facts about the properties of the actual things that exist in the world and their interactions with each other. The natures of properties that are essential to the objects are essential to them but that does not entail that these very properties and objects exist. However, given that they do exist, on this view it is physically necessary that they then have certain *dispositions* to manifest a certain behaviour under certain conditions. For example, if one object is positively charged and the other is negatively charged, they will necessarily have the disposition to produce a repulsive force away from each other in virtue of their powers (this is not to say that they will move apart, for there may be a compressive force acting on them greater than or equal to the repulsive force — see Bird (2010) for discussion of powers and causation). Thus unlike Armstrong's picture, the physical necessity is in the nature of the dispositions of the properties and not in the relations between them.

v. There are no laws (Antirealism): law statements are not fact-stating. There are many positions within this, for example that law statements are expressions of attitudes (e.g. Blackburn) or that laws are only approximately true (e.g. Cartwright). In taking this stance on lawhood, the challenge is then to explain the order in a lawless reality (Carroll 2016). One might choose to take option (4) of a powers ontology seriously while arguing that the manifestation of powers does not amount to lawhood, or one could attempt to analyse nomic concepts such as counterfactuals without referring to laws.

I have thus far established the different kinds of necessity and the relationship between physical necessity and natural facts, and I have shown how the prominent views regarding lawhood think of lawlike natural facts. Having established this, I will address determinism, which I take to define nomic closure. I will investigate what determinism is in terms of lawlike and specific natural facts, and what it means for the different views of lawhood outlined above.

III. Determinism

In this section I will discuss a potential consequence of physical necessity — determinism — which I use to define nomic closure. Determinism is a significant example of closure which also brings together the important issues of lawhood and necessity. Understanding determinism within the explanation I have provided in this chapter will allow me to combine these ideas and facilitate the framework to assess them.

I define determinism as follows: a world is deterministic iff there is exactly one set of world-states compatible with both the lawlike natural facts and the world's state at time t[3].

Very much in the spirit of this project, Earman (1986) notes that it is difficult to even articulate a definition of determinism without specifying a complete philosophy of science, since it spans so many concepts and issues such as lawhood, spacetime, and causation. For example, it is important to address the fact that many of the formulations noted above are clearly very closely linked to the existence of laws, and more specifically laws as 'pushy explainers' (see Maudlin 2007) such that laws are entities that have an active role in the evolution of the state of the universe.

As such, in the remainder of this section I will consider four key topics for determinism: its relationship to theories of lawhood, lawlike necessity, epistemology, and settledness respectively.

I will firstly look at what determinism looks like for each of the views of lawhood I have considered. What kind of active role the laws have depends on your view of lawhood. Determinism is one of the consequences of physical necessity only if one takes the lawlike natural facts — be they the contents of the laws, property natures in

[3] See Hoefer (2016), Barnes and Cameron (2008), and Earman (1986) for alternative formulations.

question, or something else — along with a maximally specified state of affairs to necessitate each consecutive state of affairs.

For the universalist, power theorist and the primitivist, lawlike natural facts have this 'pushy explainer' quality: lawlike natural facts represent entities or dispositions whose existence contributes to causing states of affairs to systematically turn out a certain way. The universalist claims that laws are necessary relationships between properties, so they play an active role in the explanations of change in the world.

When looking for an explanation of why state a evolved into state b, one looks to the properties of state a and can give it due to the lawlike relationships between the properties of the two states. For example, for a universalist like Armstrong, the Lorentz force law is the necessary relationship between the force, electric charge, instantaneous velocity, and electric and magnetic fields. A deterministic version of this view would involve the claims that a) there are no universals such that the relationships between properties are probabilistic, and b) that given the maximally specified properties of one state and the lawlike relationships between them, there is only one possible set of compatible world-states.

For the primitivist there is a similar story, except instead of necessary relationships between properties, the laws are just laws. If one asks the primitivist why state a deterministically evolved into state b, they would respond with an explanation of how the laws affect objects. For example, the Lorentz force law is a primitive fact about our world and dictates that the only compatible evolution of state a is state b.

For the Powers theorist, things are a little different: the lawlike natural facts are that given a specific property or properties an object has, it has the power to exert a certain influence. A common formulation of this is that if certain conditions are met (there are no relevant opposing forces), a certain object will exert a specified power. In the Lorentz force law example, a particle has the power to exert a certain magnitude of force F given the presence of conditions such that there is a certain electric charge, instantaneous velocity, and strengths of electric and magnetic fields, plus no relevant opposing forces are acting. Thus, a deterministic version of this theory would tell us that at time t, given all of the powers that an object possesses plus the context that it is situated in, there is only one possible state the object could be in at time t+1.

On the other hand, the BSA and No Laws approaches to lawhood do not have this 'pushy explainer' quality, in that the laws do not play the same sort of active explanatory role in explanations. The BSA tells us that laws are the patterns in local matters of fact such that they provide the best explanations for phenomena, so the laws have a more passive role in explanation. They aren't entities in themselves that determine the evolution of state a to state b, rather they are patterns in the evolution of state a to state b, b to c, c to d .. etc.

According to the BSA, laws do not determine the states, the states determine the laws. For the Lorentz force law, the BSA theorist would claim that it is part of the best system of explanation; it provides a relatively simple and strong explanation of the individual instances of the behaviour of particles in the presence of an electromagnetic field.

If we remember that determinism is the claim that only one set of successive states is compatible with the lawlike natural facts and the world's state at time t, we can understand what it means for the BSA. A deterministic version of the BSA would consist in the claim that the instantiation of the lawlike natural facts based on patterns in local matters of fact are not compatible with any other set of world-states.

The No Laws approach, however, tells us that there are the specific natural facts, and that is all. We have no reason to believe that there is anything worth the name law. There may be various reasons for believing this, but one is given by Cartwright, who argues that when it comes to laws, 'I urge that we give up on truth altogether for much of what gets labelled 'scientific principle'. Not that these principles are false. Rather that they are not candidates for truth or falsehood.' (Cartwright 2019).

This is, she argues, just not what nature is like: the evidence does not support the conclusion that there are truth-apt entities. This does not mean that we cannot make successful predictions or models about the world, simply that in doing so we aren't aiming at *truth*, especially not truth about some necessary features of the world. Since the definition of determinism involves lawlike natural facts, the question of determinism cannot apply.

Secondly, it is not the case that the truth of determinism entails that the lawlike natural facts could not have been otherwise. What is in question is whether it is determined at some time t whether a state of affairs S will obtain at some later time t+n in some world w. For example, it might be the case that given the laws of nature in w and the state of w at time t_0, it is determined that S_1 will obtain at t_1, S_2 will obtain at t_2, and so on.

Determinism simply states that *given* the way the lawlike natural facts are in a world w with a specific world-state at time t, that specific natural facts must be one way only (that all other combinations of specific natural facts are ruled out). To say that the lawlike natural facts could not have been otherwise is a further claim that would have to be made on the basis of a further metaphysical necessity.

This distinction is important to the relationship between determinism and another view: fatalism. Fatalism tend to be ill-defined, but either a) fatalism and determinism are the same, or b) fatalism has to be something stronger. It seems to me that the only way the thesis can be made stronger is if certain things (that is, the law like natural facts or the world-state at t) *do* exist of necessity.

Thirdly, it is important to note that determinism should not be characterised in terms of epistemic notions such as prediction. Regardless of whether we can (even in principle) have knowledge of these future determined states, it may still be the case that they are deterministic. For example, determinism is often explained in terms of Laplace's demon, whose explanation relies on prediction:

> 'An intelligence knowing all the forces acting in nature at a given instant, as well as the momentary positions of all things in the universe, would be able to comprehend in one single formula the motions of the largest bodies as well as the lightest atoms in the world, provided that its intellect were sufficiently powerful to subject all data to analysis; to it nothing would be uncertain, the future as well as the past would be present to its eyes' — Laplace (1820)

This is an idea that has been highly influential, but is problematically epistemic in nature when defining determinism. Determinism is distinct from predictability — as we can see from the definitions presented earlier in this section, determinism has to do with the laws of nature and what they entail, regardless of our knowledge of them. Further, as Cartwright (2019) notes, we may be able to accurately predict future states of the world without such criteria being met.

Being able to understand and articulate consistent patterns in specific natural facts provides *evidence* that the world is deterministic, but it does not constitute certainty: it

would not ensure firstly that this has anything to do with lawhood, and secondly that things could not have been otherwise. For example, it is possible that the world is deterministic but unpredictable even in principle, a significant case of this being indeterminacy in quantum mechanics.

As noted by Bishop (2017), it is an open question as to whether indeterminism in quantum mechanics is epistemic or ontological. There are many different theories regarding the nature of quantum phenomena, some of which are indeterministic and some of which are deterministic. For example, one popular interpretation of quantum mechanics is the Copenhagen interpretation[4], which is based in ontological indeterminism. In other words, according to these theories not only can we not predict the outcome of a quantum event, but they are unpredictable even in principle. Put very simply this is because they are fundamentally probabilistic, so even complete knowledge of the state of the universe at a time plus the laws of nature could not be successful in prediction.

On the other hand, there are fully deterministic theories such as hidden variable theories (i.e. de Broglie-Bohm) and branching theories (i.e. Many Worlds). These theories claim that any apparent indeterminism in quantum mechanics is merely epistemic; there is no deeper ontological sense in which quantum mechanics is unpredictable even in principle.

Finally, it is important to distinguish determinism from settledness. *Determinism* is when the specific natural facts are compatible with only one world given a set of lawlike natural facts and the world's state at time t, *settledness* is when specific natural facts might be compatible with more than one world but as a matter of fact we are in one of these worlds with a definite outcome.

One way to illustrate the difference between settledness and determinism is the following: assume the ontology of an eternalist, i.e. holding that every event at every time exists on an ontological par. Secondly, assume that it is a specific natural fact that either A or B will obtain with some probability given lawlike natural facts and the world's state at time t. However, as a matter of fact, B obtains.

This is incompatible with determinism as I have formulated it, as for determinism to be true the specific natural facts are compatible with only *one* world, and this specific natural fact is compatible with two worlds: one in which A obtains and one in which B obtains. On the other hand, it is settled that B, because as a matter of fact it obtains. This is compatible with the claim that given lawlike natural facts and the world's state at time t, A *could have* obtained.

Having defined and discussed determinism and how it relates to lawhood, lawlike necessity, epistemology, and settledness, I will address how these considerations bear on the nomic openness or closure of the past. I will discuss possible asymmetry in openness and why one might want this, focussing on asymmetry in the physical phenomenon of entropy as a way to ground a direction in time while maintaining determinism.

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[4] Other indeterministic approaches include objective collapse (GRW), Consistent Histories, and QBism.

IV. Nomic Openness and Closure of the Past: Entropic Asymmetry

One thing that is important to address before putting nomic and ontological aspects together is what the views discussed have to say about the nomic openness or closure of the past. For nomic openness of the past to be true, there must be more than one set of past states compatible with the lawlike natural facts and the world's state at time t. This seems perfectly possible, since it does not mean that things did not turn out a certain way, it simply means that it is consistent with the lawlike natural facts and the world's state at time t that it could have been otherwise.

A nomic asymmetry would consist in saying that either the past is indeterministic and the future is deterministic, or the past is deterministic and the future is indeterministic. The difficulty with the combination of lawlike closure of the past and openness of the future is that the laws of nature are to our best knowledge time symmetrical (see Albert 2000 and Earman 2002 for alternative explanations). This means that the laws apply in exactly the same way to the past and the future direction for any given state of the world.

Thus I disregard nomic asymmetry out of hand for the following reason: if determinism is true, there is only one set of possible states compatible with the lawlike natural facts and the world's state at time t. This omits the possibility of asymmetry for two reasons: firstly, since the lawlike natural facts are to our best knowledge time-symmetric, if they are deterministic in the future direction they will be so in the past direction. Secondly, determinism is something that holds for *all* times, and thus cannot change in status over time.

However, there do seem to be lawlike asymmetries in nature. Can *specific* natural facts look different in the past and future, such that they create a lawlike pattern? The answer that statistical thermodynamics gives is yes.

To use a common example (e.g. Maudlin 2012), when isolated from outside influence, an ice cube will melt into a puddle, but a puddle will not form into an ice cube. However, 'the laws of physics seem to allow the latter process just as much as the former.' (p167). So why is it that we never see the spontaneous formation of ice cubes from puddles?

This asymmetry is commonly justified by appealing to the physical phenomenon of entropic increase in thermodynamics. Thermodynamics is the study of how energy behaves over time in a system: it explains phenomena such as the flow of heat from hot to cold and the spread of gas from concentrated in one area to diffuse throughout a space.

Callender (2016) identifies two key questions regarding thermodynamic asymmetry:

'(1) What grounds the thermodynamic asymmetry in time? In a world possibly governed at bottom by time-symmetric laws, how do the time-asymmetric laws of thermodynamics arise?

(2) Does the thermodynamic time asymmetry ground any other temporal asymmetries? Does it account, for instance, for the fact that we know more about the past than the future?'

In this section I will be concerned with the first question, and will address the second in the last chapter. As noted by North (2011), 'Boltzmann and others realized that, given the time reversal invariance and determinism of the underlying dynamical laws, the second law of thermodynamics can't be a strict law. It must instead be a *probabilistic* law. Entropy decrease is not impossible, but extremely unlikely.'

The first law of thermodynamics tells us that the change in the internal energy of a system is equal to the energy supplied as heat minus the thermodynamic work done on the surroundings. Thus, a system with the highest amount of thermodynamic work available is one where the energy supplied as heat is maximal and the thermodynamic work done on surroundings is zero. In other words, the system has the highest potential energy possible to transfer to this work. What would a state like this look like? To understand this, we need to understand the relationships between microstates and macrostates.

A *microstate* is a specification of the position and velocity of each particle in the system. Then *macrostates* are, in short, different configurations of particles in the system. As such, each macrostate is then realised by certain microstates, and how probable it is that a macrostate occurs is determined by the number of microstates that can realise it.

This can be represented on a phase space diagram: a diagram that represents values for 3 dimensions of position and 3 dimensions of velocity. If we give every microstate that realises a given macrostate a different area, this would give us what Frigg (2008) calls the Macroprobability[5] of a state using the Proportionality Postulate: 'the probability of a Macrostate M_i is proportional to the measure of its corresponding macro-region'.

This is important because the higher the number of microstates in a macrostate, the higher the *entropy* of the configuration. The Boltzmann entropy of a system is defined by the following fomula: $S_{Boltzmann} = k_B \ln W$, where S is entropy, k_B is the Boltzmann constant, and $\ln W$ is the natural logarithm of the number of microstates corresponding to the macrostate. Thus, the higher W is, the higher the entropy.

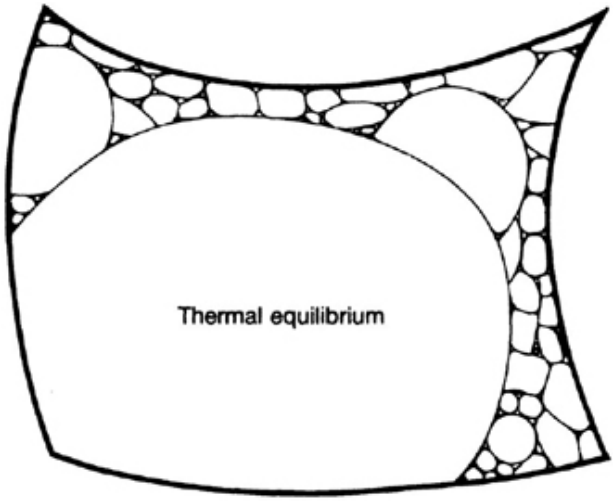

Figure 7: from Penrose (1989). Description reads: 'A coarse-graining of phase space into regions corresponding to states that are macroscopically indistinguishable from one another. The entropy is proportional to the logarithm of the phase-space volume.'

As it turns out, a vastly greater area of this diagram will allocated to one macrostate: thermal equilibrium. This is illustrated in figure 7 (right). Since each of these particles have energy, over time they will move and create another configuration. Such change is called the *evolution* of the system. From what we now know, statistically it is vastly more likely that a configuration in one of the smaller areas of phase space will evolve into one of the larger ones (with the most likely being thermal equilibrium), and not visa versa.

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[5] In contrast, the microprobability assigns probabilities to sets of microstates rather than macrostates; instead of being to do with the probability of macrostate A evolving into macrostate B, it is concerned with the probability that a given microstate m in a certain set will evolve towards a set with higher entropy.

This tells us that the entropy of a system is statistically likely to increase towards the future, so it gives us a physical process that only goes one way in time. So this gets us off the hook of the time reversal invariance of laws. Or does it? In fact, given some state of the system, this is *not* guaranteed. The laws of thermodynamics work in exactly the same way in both directions from any specified state.

One solution advocated by Albert (2000) and Loewer (2012) is positing a 'past hypothesis'. This entails assuming that the initial state of the universe was one of low entropy. Given this and any given state now, it is overwhelmingly likely that the universe will increase in entropy. This is appealing for a number of reasons, not least that — as North (2011) puts it — 'the past hypothesis makes it overwhelmingly likely that the correlations among our current records and memories are due to past states of the world'. This is exactly the sort of thing we are looking for if we want to say that there is an objective direction of time.

Is it really that straightforward? Even if we do accept this argument and agree that entropic increase does ground a physical direction of time, what does that mean within the framework that I have discussed, and for the openness and closure of the past and future?

First of all, it is important to note that temporal asymmetry between the past and the future is not the same as the difference between the closure of the past and openness of the future. Temporal asymmetry has to do with justifying differences in direction, whereas differences in openness and closure have to do with justifying differences in status between objects, laws, knowledge, etc. between past and future.

However, there is an important link between the two in that it is possible to use the latter to justify the former. For example, temporal asymmetry can be grounded in ontological asymmetry by being a Growing Block Theorist, claiming that the past is ontologically closed and the future ontologically open.

It is important to remember that entropic increase is a type of physical asymmetry, namely it is a natural fact about the world. Thus, if someone grounds temporal asymmetry in entropic increase they are then free to hold whatever ontological, nomic, and semantic views of time that they wish. In short, though difference in state of the past and future might ground a difference in temporal direction, what it means for openness is not given to us by the theory. Entropic increase cannot tell us anything about whether the future exists, whether the world is deterministic, nor whether all propositions about the future have determinate truth values. All it tells us is if the future exists, there is a high probability that the entropy of the universe will be the same or higher.

Importantly, it follows that it is possible for the past to be either nomically open or nomically closed, because this is to do with whether the world is *deterministic*. Since determinism tells us that there is only one set of world-states compatible with the lawlike natural facts and the world's state at time t, we can conclude that a physical temporal asymmetry has little to no bearing on nomic openness and closure.

This is because the physical temporal asymmetry is compatible with both determinism and indeterminism. That the state of maximum entropy is the most likely state is not a logical fact, it is a probabilistic fact that is dependent on facts about this particular world we live in. The physical facts about the behaviour of particles that make up a system are lawlike physical natural facts, and the facts about their particular position and momentum at any given time are specific natural facts.

Further, entropic increase — the thing we wish to ground temporal asymmetry in — is not a lawlike natural fact but a specific one. This is due to the fact that for it to be

true, there must be certain initial conditions present in the universe, namely a low entropy condition. If this were not the case, we would again run into trouble with time reversal invariant laws.

They important question left to ask is this: is the physical asymmetry of entropic increase sufficient to give us temporal asymmetry? Asymmetry can come in many forms: it may be physical, ontological, nomic, semantic, or something else. It may be the case that *all* of these asymmetries exist, but the important question for us is of which type or types are sufficient to ground temporal asymmetry.

This is crucial to our discussion because the answer affects the combinations of views of temporal openness and closure of the past and future that it is possible to hold. For example, someone that claims that the physical asymmetry of entropic increase is insufficient to ground temporal asymmetry must look elsewhere. They might then ground temporal asymmetry in ontological asymmetry, for instance, by accepting the Growing Block theory of time.

On the other hand, for those who want to maintain a symmetry in openness and closure of the past and future in ontological, nomic, and semantic respects, entropic increase gives an explanation of temporal asymmetry so long as they show it is sufficient alone for temporal asymmetry.

I will address this possibility in the final section of the chapter, surveying the combinations of openness and closure of the past and future that I have touched on thus far in the project: ontological and nomic. In doing so I also set the discussion up for the final chapter regarding asymmetries of truth and knowledge, giving an explanation of the combinations and compatibilities.

V. Combining Ontological and Nomic Positions

What I will do in this section is explore the different combinations of senses of openness and closure I have addressed so far in this project. In doing so, I will also address how each combined position might ground a temporal asymmetry within their view. Below is a table showing the logical space of these combinations.

Ontologically	**Source of Asymmetry**	**Plausible?**	**Examples of this view**
Open	Ontological	Y	Growing block (with or without determinism)
Open	Nomic	N	Presentism (with asymmetric determinism)
Open	Physical	Y	Presentism (with or without determism)
Closed	Ontological	N	Shrinking block (with or without determinism)
Closed	Nomic	N	Eternalism (with asymmetric determism)
Closed	Physical	Y	Eternalism (with or without determinism)

i) Ontologically Open + Nomically Open Future

On this view, the future either there is more than one future or one does not exist, and the future is indeterministic. There are three viable options regarding justifying a temporal asymmetry: firstly, one can justify the claim using ontological asymmetry alone, secondly one can justify the claim using another type of asymmetry (e.g. physical) alone, and thirdly one could justify it using both. Lastly, one has the option to deny a temporal asymmetry altogether. One must then provide an explanation of the appearance of an asymmetry, for example giving a genealogical explanation for the experience of temporal asymmetry that is sufficient to justify it.

The first option would be to take the Growing Block view of time discussed in chapter 1, where the past exists but the future does not. This is compatible with the claim that ontological asymmetry is sufficient alone to justify temporal asymmetry; it is then possible to hold any combination of nomic or semantic openness and closure, given they are internally consistent.

We cannot do this by taking a branching Eternalist view of time, however, since there are multiple pasts that exist. To be ontologically closed towards the past and open towards the future, one would need a single past and more than one future. However, since all branches are on an ontological par, many parallel pasts will exist at any time t on other branches. If we want to take a branching Eternalist ontology, we will have to accept ontological openness to both the past and future.

The second option of appealing to an alternative asymmetry is consistent with the claim that ontological closure of the past and openness of the future is insufficient to justify the relevant temporal asymmetry. Options for this might include physical entropic asymmetry, epistemic asymmetry, and an asymmetry of influence. Most notably for this chapter, one can argue that temporal asymmetry can be justified using the increase in thermodynamic entropy along with the past hypothesis as discussed in 2.IV. This is distinct from justifying temporal asymmetry with nomic asymmetry as it concerns only specific natural facts, thus this asymmetry is *compatible* with determinism in both directions.

As I noted in 2.IV, it is implausible to ground the temporal asymmetry only in nomic asymmetry. The relevant claim would be that the lawlike natural facts are deterministic in the past direction but indeterministic in the future direction. However, this is implausible, since determinism tells us that the laws of nature and the world's state at time t entail that there is only one set of world-states that are possible, while indeterminism denies this. What would a deterministic past and an indeterministic future look like? There would be only one set of past states compatible with the laws of nature and the world's state at time t, while there would be more than one set of such states for the future.

One might reply that lawlike natural facts make specific natural facts settled in truth value as time passes. This would mean that there are specific natural facts about the past but not the future. However, this is implausible because determinism is about *compatibility* with sets of world-states, not whether the truth values of the actually obtaining states are settled. Such a claim would be to say that nomic closure entails semantic closure, which is not what is at stake here: I will discuss this in chapters three and four.

To see the incoherence of a deterministic past and an indeterministic future, we can simply consider two times p1 and p2, where p2 is later than p1. When p1 is present, there are more than one set of past states compatible with the laws of nature and the world's state at time t, and only one such set for the past. However, when p2 is present, the same is true, and this can be consistently repeated.

In terms of theories of lawlike natural facts this combination is compatible with, ontological and nomic openness give us some options that are less appealing. For example, when combined with the BSA account of lawlike natural facts, the result is unappealing. This is because if the laws are those specific natural facts that appear in their best systematisation, this systematisation will only include what exists.

Ontological openness of the past and future generates two difficulties based on this fact. Firstly, the supervenience base for the BSA laws may be small if we are Presentists or hold the Growing Block view. Thus, there will be relatively few states of affairs available from which to derive the patterns that the BSA theorist takes to be laws. Secondly, the supervenience base will change over time: for the Presentist, all that exists is the present moment, which means everything in the supervenience base

changes at every time, while for the Growing Block theorist the supervenience base grows at every moment.

This leads to the possibility that the laws can change over time: since the patterns in the supervenience base determine the laws and not the other way around, there is nothing to guarantee that the patterns will remain constant over time. This a problem for both the Presentist and the GBT, since there is no guarantee that the specific natural facts even a moment in the future will contain the same patterns as the present. The skeptical possibility that the laws can change at each moment is not only applicable to the Presentist whose BSA laws would only have present matters of fact to supervene on, but also the GBT. In particular, though the total supervenience base at t+1 will contain all the same matters of fact as at t, the overall patterns in the two supervenience bases — and thus the laws — may be different.

If one chooses branching Eternalism, the supervenience base will be larger and one might be able to avoid this issue given nomic openness.

On the other hand, one can hold a governing law theory such as universalism or primitivism about laws. Since these laws dictate the specific natural facts in the world and not visa versa, we no longer have the problem of the laws changing over time. Since this is an indeterministic combination, there is more than one set of states of affairs compatible with the lawlike natural facts and the world's state at time t. However, these possibilities are always the result of laws, and they constrain what future states can be. Thus, there is no skeptical worry about laws that comes when combining with Presentism or GBT.

Alternatively, one can hold a No Laws view. This would be perfectly compatible with this combination, since there are no laws to require a supervenience base. However, one would need to both find an alternative way to account for the significance of patterns in the world and provide an alternative justification for any predictions made about the future.

ii) Ontologically Open + Nomically Closed Future

As with (i), the same four options are open regarding temporal asymmetry: firstly, due to ontological openness it is possible to justify a temporal asymmetry with ontological asymmetry alone by advocating a Growing Block ontology. Secondly, one could opt for an alternative asymmetry alone, such as physical. Thirdly, one can claim that ontological asymmetry can only justify temporal asymmetry when combined with another asymmetry, such as a physical one. Lastly, one could reject a temporal asymmetry altogether.

It is also important to note that the branching Eternalist option is not tenable here. This is because there by definition is more than one branch, and thus more than one set of world-states, compatible with the world-state at t. Thus, it must be nomically open.

The second option — a physical asymmetry within the *specific* natural facts such as that of entropic increase — may be claimed to be especially well suited to justifying a temporal asymmetry. This is because the nomic closure of this view entails there is exactly one set of specific natural facts possible in this world given either the lawlike natural facts plus the world's state at time t. When combined with ontological openness, this gives us a guarantee that the physical asymmetry obtains and rules out any skeptical scenarios, such as that entropy suddenly decreases.

Also as with (i), the BSA will be a less attractive theory of lawlike natural facts alongside this combination, since the laws will have fewer existent specific natural facts to supervene on. Thus, they may not only be difficult to determine but may change over time. To see why this is potentially problematic, we can imagine a sceptical scenario where up to the present day, the world has been such that all As are Bs. This gives us a great deal of useful information about As and Bs in a simple way, and thus we include it in our best systematisation of specific natural facts, making it a lawlike natural fact.

Then imagine that after the present day all or some As stop being Bs, without any other change. The BSA theorist would be forced to deny that this was a law in the first place, and also explain why this should happen. This is especially troubling in a deterministic picture, since only one set of states of affairs is compatible with the lawlike natural facts and the world's state at time t. Why should all As have been Bs up to today? It seem that this pattern is still significant even if not universal, and the BSA theorist cannot justify nor explain this.

Importantly, the determinist BSA theorist does not have a way to deny that this will happen: unlike the Universalist, Primitivist, or Power theorist, who all claim that the lawlike natural facts are something that determine the way the world is, for the Humean view the dependence is reversed. Thus, these latter positions may be more appealing to those who choose combination (ii). In sum, this combination as it stands is implausible for the BSA theorist, and they should opt for other combinations. As we will see in chapter four, however, the additional consideration of semantic closure dramatically affects its plausibility.

iii) Ontologically Closed + Nomically Open Future

With this combination, it is only plausible to be an Eternalist, since it would be difficult to motivate the view that the past does not exist while the future does. This is then paired with the view that there is more than one set of specific natural facts possible given the lawlike natural facts and specific world-state at time t of this world. Thus, if one wanted to justify a temporal asymmetry the only viable option that we have discussed thus far is to claim that an alternative asymmetry such as physical is sufficient.

Having a BSA view of lawlike natural facts is more appealing for this combination due to its ontological closure component. Since lawlike natural facts for the BSA are those patterns in specific natural facts that appear in the best systematisation of specific natural facts, having events at all times to supervene on will avoid the problem of the possibility of laws changing over time.

How indeterminism works for BSA and Eternalism might be something like a frequestist formulations of probabilistic laws. For example, for some probabilistic lawlike natural fact, its probability would be calculated based on the frequency of outcomes of related specific natural facts. Thus, though there is only one way things actually do turn out, this is not made so simply by the lawlike natural facts and the world's state at time t.

We can illustrate this in the following way: let's say there is a lawlike natural fact that tells us that whenever A occurs there is a 50% chance of B occurring and a 50% chance of C occurring. This has been calculated from the patterns of As, Bs, and Cs in the world, which are that whenever A occurs, half of the time B occurs and half of

the time C occurs. However, it is consistent with this regularity that any one of those instances of A could have had the other outcome, meaning that there is more than one set of states of affairs compatible with the lawlike natural facts and the world's state at time t.

On the other hand, Universalism tells us that lawlike natural facts are necessary relationships between types of property. With combination (iii), this amounts to saying that the relationship between some universals A and B is intrinsically probabilistic, a significant account of this being that of Armstrong (1985, chapter 9). One way probability could be cashed out is if, for example, A occurs then B occurs 70% of the time. For any instance where A and B both occur, it is *compatible* with the lawlike natural facts that B did not occur even if this does not happen as a matter of fact. Thus there are more than one set of specific natural facts compatible with the lawlike natural facts and the world's state at time t.

For a Powers metaphysic, powers are capacities to produce certain outcomes, that are relevant in virtue of the object's properties. The indeterminism could come from positing that a power is 'multi-track', meaning that for one power there are many compatible outcomes such that it is indeterminate which one of the multi-track manifestations will be produced in any case. This also requires the claim that the exercise of the power is probabilistic independent of the circumstances that activate the power, for example the probability of object O manifesting power P given circumstances C is 70%. However, there are many who would not want to accept this and instead claim that the exercise of the power is deterministic; the probability of object O manifesting power P given circumstances C 100%.

iv) Ontologically Closed + Nomically Closed Future

With this combination, one must be an Eternalist and hold that there is only one way the specific natural facts could be given the lawlike natural facts and the world's state at time t. As with (iii), the only viable option thus far for justifying a temporal asymmetry, if one considers this necessary, is physical.

However, it is still possible to hold different views of what the lawlike natural facts are like. I claim that this combination is the most amenable to the BSA view of lawhood, since the specific natural facts the laws supervene on are those for all times. Thus, as with (iii), there is no chance for the laws to change over time.

It is also possible to hold another theory of lawhood, as long as it takes a deterministic form. The way this is cashed out will be identical to (ii), as whether the future exists or not is irrelevant for a theory of lawhood whose lawlike natural facts do not supervene on their instances. To see this, note that the lawlike natural facts are only compatible with one set of world-states given the world's state at time t, whether or not these states exist; compatibility does not require existence.

This is true because such lawlike natural facts determine which world-states are compatible given the world's state at time t, unlike the BSA where the opposite is true: the world-states determine the laws.

What have we learned from this chapter? Firstly, there are two types of natural facts about the world: lawlike (roughly those that make general claims about the world) and specific (roughly local matters of fact). There are many different characterisations of the former category, the most prominent of which I have focussed on in this

chapter: the Best System Analysis, Necessitarianism, Primitivism, Powers, and No Laws.

Secondly, I define nomic closure as determinism: that there is only one set of world-states compatible with both the lawlike natural facts and the world's state at time t. Nomic openness, and thus indeterminism, is the denial of this claim.

Thirdly, an asymmetry of nomic openness and closure towards the past and future is untenable due to the time-reversibility of lawlike natural facts. However, there is a possible asymmetry in the specific natural facts due to entropic increase. This physical asymmetry could be used to justify a temporal asymmetry should one not either justify it in some other way or take it as a brute fact.

Finally, when combined with the ontological positions discussed in chapter one, we come to see that some of these combinations should be discounted, and that some are more tenable for certain views of lawlike natural facts than others. For example, BSA views do not work well with an ontologically open future since it reduces the supervenience base for the lawlike natural facts and opens up the possibility that the laws can change over time. On the other hand, the views of lawlike natural facts that hold that such facts determine the specific natural facts are not affected in this way by ontological openness and closure.

In the next chapter I will discuss semantic and epistemic openness and closure, the final considerations before combining these with the six remaining combinations from this chapter to create the final combined views of openness and closure of the past and future.

CHAPTER THREE
SEMANTIC AND EPISTEMIC OPENNESS AND CLOSURE

Having discussed both ontological and nomic openness and closure, in this chapter I will discuss the final considerations that I will explore at length: semantic and epistemic openness and closure of the past and future. As I will define it, to be semantically closed is for *all* propositions about the future to have determinate truth values for all times, while to be semantically open is to deny this. On the other hand, for the future to be epistemically closed is for it to be possible for the current scientific community — with their current scientific understanding and computational power — to have knowledge of *all* future states, and to be epistemically open is to deny this. There can be levels of semantic and epistemic openness, due to the fact that to be semantically or epistemically open is compatible with anything on a spectrum from *all* future states not having a determinate truth value for all times or for it to be impossible for the current scientific community to know the truth of any future state, to *all but one* future state not having a determinate truth value for all times or for it to be impossible for the current scientific community to know the truth of all but one future state.

Semantic and epistemic openness are importantly related: in order to have epistemic closure it is necessary to have semantic closure, because if a proposition about the future does not have a truth value, one can't have knowledge of its truth. However, the dependence does not exist in the reverse direction: a proposition can have a determinate truth value without the possibility of the current scientific community knowing if it is true. An example of such a proposition might be one regarding the outcome of a quantum measurement.

The chapter will introduce semantic and epistemic openness and closure of the future, as well as exploring how they can be applied to the past. The discussion of the semantic openness and closure of the past will be centred around Markosian's 1995 paper 'The Open Past', and the discussion of epistemological openness will be centred around the discussion of records and evidence.

I chose to examine Markosian's paper for two reasons:

Firstly, this paper represents a paradigm example (and one of the only examples in the literature) of the relationship between the openness and closure of both the past and future.

Secondly, it represents an example of where my taxonomy of ontological, nomic, semantic, and epistemic closure can be advantageous. In analysing this argument with my framework in mind, I can dissolve the problem that Markosian begins with, and instead show that these views can be compatible.

I will then address a significant consideration for both semantic and epistemic openness and closure: truthmaking. In short, the truthmaking principle tells us that for every true proposition there must be something that is sufficient to make it true. This raises interesting questions and possible solutions for the combinations of ontological, nomic, semantic, and epistemic views, especially when considering propositions about non-present times.

For example, if there are matters of fact about the laws of nature there might be an extent to which there are true propositions about future states that we can know now. If determinism is true and we know the exact and complete state of the world

now, it follows that there are true propositions about every future state, which would allow the possibility of knowledge about these states.

I end the chapter by evaluating Markosian's solution to fatalism, and using the framework I have created to explain firstly why the problem he provides a solution to can be dissolved, and secondly why his solution is not the only one that would give semantic openness. Having done so, I will have sufficiently developed my framework to evaluate the possible combinations of the different senses of openness and closure of the past and future I have discussed and conclude with my findings.

The aim of this chapter, then, is to investigate the semantic and epistemological senses of the openness and closure of the past and future with a view to exploring what a complete view of openness and closure of the past and future looks like in the next chapter. In that chapter, I will put together the views discussed in chapters one to three and evaluate their combinations.

I. Semantic closure

In my framework, to say that a world is semantically closed means that every proposition has some determinate truth value, and this truth value is the same at every time. Determinateness tells us that the truth value of a proposition cannot be unsettled. This does not amount to the claim that bivalence — that a proposition must be either true or else false — is true. Rather, it can be determinate that a proposition could have a 'gappy' truth value, such as a third truth value of neither true nor false.

I also claim that determinateness entails that the truth of a proposition cannot change over time. However, there is an additional consideration within semantic closure that means that this component is more difficult to state. That is, there is a crucial distinction necessary to understand of semantic closure; that between tensed and untensed semantic views. This distinction is commonly marked by what McTaggart originally named the 'A series' and the 'B series'. Zimmermann (2005, p 401) summarises them thus:

> '…being past, being present, and being future are generally called the 'A-properties'. The relations of being earlier than, being later than, and being simultaneous with, are the 'B-relations''.

These two views differ in what they take the *propositions* that the uttered sentences express to be. Propositions are the linguistic objects that truth value can be attached to; they can be true or false. On the other hand, sentences are how the propositions are expressed in speech.

Take the sentence 'I'm going to New Zealand next summer'. Given it is uttered in December 2019 and we are in summer 2021 and not going to New Zealand in 2022, what is the truth value of the proposition expressed by this sentence?

On the tensed view, the proposition that was expressed by the token utterance 'I'm going to New Zealand next summer' is false. Rather, 'I went to New Zealand last summer' is true. This is because according to the tensed view, there are tensed properties of pastness, presentness, and futurity. In uttering this sentence, I am attaching the property of futurity to my being in New Zealand.

On the untensed view, 'I'm going to New Zealand next summer' is true. The sentence was uttered in summer 2019, so the proposition being expressed is something like what is expressed by 'Anaïs is in New Zealand in summer 2020'. On the untensed

view there are no tensed properties, only relations between times. Thus, the proposition is one about the relationship between two times: summer 2019 and summer 2020. The consequence of this is that this proposition is true for *all* times, unlike the tensed proposition which changes in truth value.

Therefore, semantic closure can be defined in two ways, one for untensed semantics and one for tensed semantics.

Untensed: the future is semantically closed iff every proposition regarding the future has a determinate truth value, and it has this same truth value at all times. Since P has no properties that depend on temporal position — only those that depend on the relationship to some other event — the truth of P is fixed for all times.

Tensed: the future is semantically closed iff every proposition regarding the future has a determinate truth value, and it has this same truth value when it is past, present, and future. For any given proposition P, P's truth will change over time as the event from which it derives its truth changes temporal properties from past to present to future. Thus to formulate an unchanging truth value we need to disjoin the truth value of P's truth value for every tense.

It is important to note here how this relates to the semantic views of those such as Łukasiewicz. Such views hold the future to be open precisely because some future propositions have indeterminate truth values, and when they become present they gain determinate truth values. Thus, these are tensed positions and would require both an ontologically and nomically open future (given that either ontological or nomic closure is sufficient for semantic closure: I argue for this in chapter 4 section (i)). As a result, whether one endorses a three-valued logic is independent of whether the world is semantically closed. The view discussed here would count as semantically open on my view, since the truth values of propositions change over time, whereas one can also endorse a three-values logic with the truth values of all propositions remaining constant for all times. This is also to be contrasted with supervaluationist logics, which do not endorse a third truth value. This view will be discussed in more detail in chapter 4 section (i). Such propositions that I see as remaining indeterminate for all times are, for example, cases of vagueness such as Sorites series.

Lastly, it is important to note that it is possible to have semantic asymmetry. Most relevantly, it is possible that the truth values of past propositions are determinate but the truth values of future propositions are indeterminate. However, there are limitations on this asymmetry when combined with the other senses of closure, which I will discuss in chapter four.

II. Epistemic closure

In my framework, to say that a world is epistemically closed is to say that it is possible for the current scientific community — with their current understanding of the contents and laws of the world, and computational power — to know the truth of all propositions about the future. There are two things necessary for epistemic closure to be possible. Firstly, as I mentioned above, in order to be able to know the truth of a proposition it must have a determinate truth value that is not subject to change over time: that is, it must be semantically closed.

Secondly, epistemic closure requires some method of coming to know the truth. There are two key ways this is possible: the laws of nature in conjunction with

knowledge of facts, and knowledge of records. These and other approaches will be discussed in section IV.

It is also important to note that it is possible for the level of epistemic closure to alter over time. Given some level of semantic closure, scientific discoveries and increased computational power will likely result in the scientific community being able to know the truth or falsity of more of these propositions.

III. Markosian and the semantic openness of the past

In 1995, Ned Markosian published a paper entitled 'The Open Past'. As the title suggests, the possibility of an 'open past' is discussed as a consequence or at least implication of an argument for the open future. In a nutshell, Markosian claims that the only 'non-question-begging' defence of the open future rests on the following claims:

1) The laws of nature are indeterministic

2) A certain version of the correspondence theory of truth is correct

He argues that these claims, if true, would also entail that the past is (at least sometimes) open. There are a few questions I'll ask to get clear on the project of the paper and its arguments.

The first question is of motivation: why would we want an open future? Markosian claims that one motivation is to resist Fatalism (which I discussed briefly in chapter 2), which he defines as 'the view that whatever will happen in the future is inevitable, due to certain considerations about truth and time' (1995, p95). He identifies these considerations as bivalence and eternalism respectively. If we lived in a Fatalistic universe, the events of the future would be predetermined, regardless of the intentions and choices of agents. Markosian states that this is sometimes argued to undermine our notion of free will, which is something that we tend to have strong positive beliefs about.

Thus, the apparent truth of our beliefs regarding free will might provide a strong motivation for arguing for an open future. What kind of open future would this require? In my framework, any theory that is not nomically closed is non-fatalistic. However, as discussed in chapter 2, it is possible for the world to be both nomically closed and non-fatalistic: namely, a world can be deterministic.

Another motivation for arguing for an open future is a discomfort with the combination of semantic closure and ontological openness. It might be unpalatable to accept that nonexistent future events have corresponding propositions that have determinate truth values. One might then want to have a semantically open future such that propositions only have determinate truth values when they correspond to existent objects and events.

The second question is of what reasons one might have for *accepting* Fatalism: these are the reasons that an Open Future proponent would have to argue against. Markosian argues that one might consider Fatalism to be true 'because of considerations about both truth and time' (1995, p95).

The grounds for the truth-based (semantic) reason are considerations about *bivalence*. The basic idea of bivalence about truth is that all propositions are either true or false, and there are no indeterminate truth values[6].

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[6] As I noted in 3.II, my framework allows for the denial of bivalence by permitting 'gappy' truth values, and I will address this difference in 3.V.

For example, the proposition 'the Metropolitan line will have severe delays at midday on 27th July 2021' has a determinate truth value at all times, even times that precede it. This might lead one to the idea that the truth or falsity of the proposition is inevitable, and thus the future will turn out a certain way no matter what we do. This is often called the problem of *future contingents*.

On the other hand, one of the grounds for the time-based reason for fatalism is the belief in eternalism: in short, the view that all things — past present and future — exist. As discussed in chapter one, for an eternalist all times are ontologically on par. The fatalist argument, then, is that if the future things or states exist as the eternalist says and these states have a determinate truth value it doesn't seem that we can have any influence over them. They already have as much ontological significance as the past and the present.

On my framework, the fatalistic argument that Markosian replies to amounts to the claim that ontological closure and semantic closure together entail fatalism, a specific form of nomic closure. I will argue in 3.V. that this entailment is false, but I will first explore how Markosian answers this challenge and attempts to resist fatalism.

Markosian tries rejecting the principle of bivalence in order to reject the fatalist argument from truth, saying that if something is a future contingent it's neither true nor false. In fact, he uses bivalence to define the open future, thus identifying the object of his concern as — in my terms — semantic closure:

> 'To say, with regard to some time, t, that the future is open at t is to say that there are some propositions about the future relative to t that are, at t, neither true nor false. To say that the future is closed at t is to deny this, i.e., to say that every proposition about the future relative to t is, at t, either true or else false.'
>
> — Markosian (1995) p96

Markosian advances two 'non question-begging' claims (1) and (2) (stated at the beginning this section) that he gives for rejecting bivalence. He then puts forward what he calls the tensed version of the correspondence theory of truth (TCT) to form the correspondence theory referred to in claim (2).

TCT states: 'For any time, t, and proposition, p, p is true at t just in case p corresponds to the world at t.' (p98)

For example if I utter the sentence "I live in London", for the TCT this expresses the irreducibly tensed proposition that looks something like 'I live in London now' or 'I currently live in London'. This proposition is only true if it corresponds to the state of the world *when its corresponding sentence is uttered*.

The two claims — (1) Indeterminacy and (2) TCT — are not trivial, nor can they be taken on their own as providing support for bivalence. For example, TCT has radical consequences for future and past tensed statements. An intuitive view regarding the future tensed statements is as follows: 'It will be raining in one hour in London' is true iff in one hour it is raining in London.

Generally what we do is wait an hour and see if it's raining, and then this determines whether what we said an hour ago was true or false. More specifically, the truth of 'It will be raining in one hour in London' at t depends on the truth of the simpler sentence 'it is raining in London' at t+1hr.

On the other hand, the TCT view is that 'It will be raining in one hour in London' is true or false in virtue of the way the world is when you utter it. This assumes that 'the way the world is' does not contain any future states or information.

The answer would then be that the truth of 'It will be raining in one hour in London' is determined by the present facts, which may include present states of affairs and the laws of nature. It is important to note here that when combined with the indeterminism that Markosian's view requires this makes it unlikely that any future propositions would have a non-trivial determinate truth value (e.g. logical necessities).

However, if Markosian's open future argument based on indeterminism and TCT is plausible, there's a strange consequence that he notes: the argument seems to hold equally well for the past direction. This is for two reasons. Firstly, TCT also applies to propositions about the past.

If for the truth of a proposition about the past we need something that makes it true when one utters it now, it seems that at least in certain cases we might be out of luck. If we can't use past events as truthmakers for our propositions, there may not be sufficient grounds for their truth. This idea of truthmaking will be addressed in detail in the next section.

Secondly, the laws are time symmetric: their reverse states in time are also allowed by the laws of nature, given that we do not take the Past Hypethesis as a law (as I discussed in chapter 2). For example, classical, deterministic Newtonian motion laws describe equally well the reverse of a process. The same goes for laws that may be indeterministic - paradigmatically those of quantum mechanics.

Thus, if one wanted to take Markosian's approach, one would have to find an independent reason for an asymmetry in openness, since one cannot be found within the theory.

IV. Truthmaking and a fixed past

If we want *semantic* closure of the past, this would mean that past propositions have a determinate and unchanging truth value. This is hard (if not impossible) to do on TCT, as it means that we have only '[the object], with all of its properties; there is the environment around [the object], and there are the laws governing these things' to ground the truth of the proposition. Thus, there has to be some asymmetry detectable in the present between the past and future.

One common example that is appealed to is the asymmetry of records. We have things like fossils, books, and memories that give us information about the past. We can use these to ground truth claims about past propositions; for example, say I have a video of my 5th birthday party. I can say "I had a Colin the Caterpillar cake at my 5th birthday party" and there is something about the present - namely the video - that gives me evidence for the truth of the claim.

However, is it enough for the TCT to have this sort of indirect evidence? There are two arguments that it is insufficient to simply have these records and infer the truth of a past proposition from them. Firstly, records are taken as *evidence* for what happened; they do not *constitute* what happened. Secondly, there is a further skeptical worry: if the evidence is indirect, there might be some possibility of the record not accurately representing the actual past event. For example, the record might have been tampered with or misrepresent the relevant information.

One way that we might be able to make this picture viable is to claim that the laws of nature are sufficiently deterministic to entail that the information contained in the records accurately represents what it purports to. However, there are two problems with this: firstly, Markosian's position is based on the fact that the laws of nature are

indeterministic. When applied to the past, this entails that there is more than one set of states compatible with the present. Thus, the present information given by records is insufficient to uniquely identify the contents of the past.

Furthermore, even if we did have deterministic laws as a presentist, this would not guarantee a unique past. There are different possible initial conditions — and thus pasts — compatible with the present being the way that it is. Determinism tells us that given the initial conditions and the lawlike natural facts that there is only one compatible set of world-states, but this does not prohibit any one of these states appearing in more than one set. Thus, unless the presentist posits a specific set of initial conditions along with the present state of the universe, they have insufficient evidence regarding the state that produced the record.

In the more general picture, as for the Markosian paper, one of the key debates that bears on the discussion of semantic openness and closure of the past and future is that of truthmaking. In simple terms, the truthmaker principle tells us that for every truth bearer (e.g. sentence tokens, judgements, propositions, etc.), that there is something (i.e. a truthmaker) that is sufficient to make, ground, or entail (or have some other similar relationship to) the truth of the truth bearer[7].

The exact nature of these three elements (truthbearers, truthmakers, and the truthmaking relation) is not essential for the discussion of semantic openness and closure of the past and future, since we could run the same arguments given all (or at least most) of the formulations. This is because what we are discussing is the implications of the principle in general, not what each specific formulation tells us.

More specifically, *something* has to exist (in the unrestricted sense) to make a truthbearer (in whatever form) true. If there are to be true truthbearers regarding the past and the future, as semantic closure states, then this will have interactions with and implications for the other senses of closure I have discussed in chapters one and two.

Caplan and Sanson (2011) discuss what they call the 'Inconsistent triad' of presentism, truthmaking, and independence (the idea that 'not all truths about the past supervene on the present'). They argue that one cannot hold all three of these together.

The inconsistency can be illustrated with an example: suppose, as independence tells us, that there is a proposition P about the past that is true, and is made true, and supervenes on objects or events at a non-present time. According to truthmaking, P is true in virtue of the existence of these objects or events. Since presentists hold that there are no non-present objects nor events, we reach an incompatibility. Thus, the presentist faces the challenge of justifying the rejection of truthmaking or independence.

To maintain presentism, one would have to reject independence or truthmaking. There are a few ways that one could attempt do this:

1) Having the truthmakers for propositions be present objects and events in combination with another component such as deterministic laws of nature or primitive tensed properties that exist now (e.g. Bigelow's 1996 Lucretian presentism; see also Tallant and Ingram (forthcoming)).

2) Having the truthmakers for propositions be abstract objects such as haecceities - properties unique to a specific thing, like being Socrates - (Markosian (2004), Ingram (2016)) or ersatz times (e.g. Crisp (2007), Bourne (2006)). These

[7] See MacBride 2020 for a full survey of these variations.

types of entities are atemporal and thus are applicable whatever the physical contents of the present are.

3) Reject TCT: the truth of propositions does not depend only on the present state of affairs. The truth of 'it will rain tomorrow' depends on the truth of the proposition tomorrow 'it is raining now', which *will* have a truthmaker. In other words, past tensed truths required (past tense) a truthmaker and future tensed truths will require (future tensed) a truthmaker.

Alternatively, one can strictly deny that past-directed propositions have a truth value (Reject P2), thus denying semantic closure. This is what Markosian (1995) does in the solution discussed above.

In sum, there is no strict incompatibility between truthmaking and presentism, though the work to be done to ground past and future truths may prove unattractive to some. However, it is also important to note at this point the following: as argued by Miller (2017), the Presentist is not the only one who faces the truthmaker problem: any account that has any change or dynamism must provide answers too. Thus, the Growing Block Theorist and the Moving Spotlight theorist must also give explanations for future propositions and tensed propositions respectively.

V. Markosian's argument and my framework

In this section I will argue that discussion of Markosian's argument represents an example of where my tripartite distinction of ontological, nomic, and semantic closure can be advantageous. In analysing this argument with my framework in mind, I can dissolve the problem that Markosian begins with, and instead show that these views can be compatible.

This can be done as follows: as I previously stated, Markosian develops this theory in response to the fatalist argument that ontological closure and semantic closure together entail fatalism, a specific form of nomic closure. Firstly, when we understand that here we are considering three different types of closure we can understand the fault in the entailment being claimed.

The tacit assumption that is being made is that fatalism is equivalent to nomic closure, which is not the case. As I explained in chapter 2, fatalism is different from determinism, a view which does exemplify nomic closure. What is necessary for fatalism to be true is that events are predetermined and inevitable, which entails claims such as that the laws of nature are metaphysically necessary and the world's state at time t could not have been otherwise. On the other hand, nomic closure tells us that the laws of nature plus the world's state at time t are compatible with only one set of events; this does not mean that the laws of nature or the world's state at time t could not have been otherwise.

Furthermore, it is perfectly possible for there to be a combination of ontological and semantic closure, and nomic openness, so even if fatalism was equivalent to nomic closure the entailment would not hold. I will explore what such a view would look like in the proceeding chapter.

Secondly, I argue that Markosian's solution has little bearing on the semantic openness he is concerned with. Markosian's claim is that the only sufficient grounds for semantic openness would be for indeterminacy (and thus nomic openness) to be

true, and for TCT (a position compatible with ontological openness, but not entailing or entailed by it) to be true.

The only thing necessary for semantic openness to be true is that the truth value of some proposition is indeterminate for all times. This has very little to do with nomic nor ontological openness. To illustrate this point, it is sufficient to explain that both nomic and ontological closure could be true, and this is still compatible with semantic openness.

Firstly, one could simply take it as a brute fact that propositions about the past and future have determinate truth values, and reject truthmaker theory. Secondly, one could hold the 'Moving Spotlight' view mentioned in chapter one, whereby there is an ontologically privileged present and certain tensed truths with respect to it. That such a views exist is sufficient to show that this combination is technically compatible and thus that the implications and entailments discussed in Markosian's paper are false.

Now that I have explained the relevant forms of closure of the future, I will go on to explore the possible combinations of the views in order to illustrate the significance of the differences in combinations. I also include a description of each view in the reverse direction in time.

The core purpose of looking at openness closure in the past direction is to identify asymmetries in reasoning and evidence between the past and future directions. If we can't explain and justify these asymmetries immediately, there is a good chance that there is some underlying elements that we need to evaluate. It may turn out that these implicit background reasonings are perfectly legitimate and rational, but even if this is so there is still work to be done in showing that it is the case.

CHAPTER FOUR
Evaluating the Combinations of Openness and Closure of the Past and Future

In this chapter, I will use my discussions from chapters one to three of ontological, nomic, semantic, and epistemic openness and closure of the past and future to consider their possible combinations. I will systematically address these combinations in order to create a holistic picture of the openness and closure of the past and future.

In the table below, I lay out the space of possibility regarding views one could take regarding closure of the future regarding three of these senses of closure: ontological, nomic, and semantic. Since — as I emphasised in chapter three — semantic closure is necessary but not sufficient for epistemic closure, I will address epistemic openness and closure in tandem with semantic openness and closure. Since the dependence runs this way and not the other way around, it will not be necessary to add an extra column into the table on the following page. However, it is important to include a discussion of epistemic closure within these combinations, since it is possible to have semantic closure without epistemic closure, meaning that the future may be closed in all senses but the epistemic sense.

The future views will be labelled with letters, and the corresponding past views will be marked with a prime. I claim that the majority of these are *logical* possibilities in that they do not contain internal inconsistencies, though there are some that come close.

However, there is also a separate issue of *plausibility*, especially in light of particular ontological, nomic, and semantic view that one can hold in conjunction with an affirmation of openness and closure within each of these categories.

	Ontological	**Nomic**	**Semantic**	**Plausible?**	**Examples of the view**	**Section**
A	Closed	Closed	Closed	Y	Eternalism with determinism	ii
B	Closed	Closed	Open	N		i
C	Closed	Open	Closed	Y	Eternalism with indeterminism	iii
D	Closed	Open	Open	N		i
E	Open	Closed	Closed	Y	Growing block/ presentism with determinism	iv
F	Open	Closed	Open	N		i
G	Open	Open	Closed	Y	Growing block/ presentism with indeterminism	v
H	Open	Open	Open	Y	Growing block/ presentism with indeterminism	vi

To refresh, a core purpose of looking at closure in the past direction is to identify asymmetries in reasoning and evidence between the past and future directions. If we can't explain and justify these asymmetries immediately, there is a good chance that there is some underlying elements that we need to evaluate.

(i) (B), (D), and (F): the incompatibility of Semantic Openness with both Nomic and Ontological Closure

I begin with discussion of three views together — (B), (D), and (F) — to eliminate them as plausible. I argue that this is because nomic closure entails semantic closure, and ontological closure entails semantic closure.

(B) and (F) are implausible because nomic closure does plausibly entail semantic closure: to be semantically open, it must be the case that future propositions do not have determinate truth values. However, nomic closure tells us that there is only one possible set of events that are compatible with the lawlike natural facts and the world's state at time t. This entails determinate truths about the nature of S, contrary to semantic openness.

I will illustrate the incompatibility for both the Humean and governing law type theories. Firstly, since the laws are deterministic, if we accept a BSA account on this picture it would be impossible to formulate the laws. This is because laws for the BSA consist in patterns in the specific matters of fact. If there are no determinate truths about such patterns, it is implausible that the laws could be formulated.

On the other hand, for a governing law type theory, the lawlike natural facts and the world's state at time t determine what the world-states will be. Thus, given these two things, there must be true statements about these states, contrary to semantic openness.

(B) and (D) are also implausible because ontological closure entails semantic closure. I will show this by arguing for the implausibility of ontological closure and semantic openness with nomic openness (D) — which is the more difficult case to argue for — and then applying this to the case of nomic closure (B).

The semantic openness component of this combination raises problems for combination with the Humean view. If there are no determinate truths about the specific matters of fact then it is difficult to see how there could be determinate truths about Humean laws either, since the latter supervenes on the former. Furthermore, there is no determinism to provide at least some truths about future states.

This is also a problem for other theories of lawhood. Nomic openness with a governing law theory entails that there is more that one set of future world-states compatible with the lawlike natural facts and the world's state at time t. Ontological closure then tells us that the future exists. The next step depends on what one takes the future states to consist of.

On the one hand, ontological closure might mean that a set of future world-states actually do exist. Thus, though there is more than one set of future *compatible* world-states, only one of those sets in fact *obtains*. This makes it puzzling to see how there could fail to be determinate truth values for propositions about these future states.

It is also important to note that applying this to the past direction, these views all entail that it is impossible make truth claims about the past, since there are no

determinate truth values about it. However, this seems to go against our intuitions, especially when combined with nomic or ontological closure.

One would have to deny that the scientific community — and indeed any of us — can have knowledge about the past, since epistemic closure requires semantic closure: that our memories and physical records are insufficient for this. If ontological closure is true, the events these records correspond to exist, and it seems implausible to claim that what the records say about such events has an indeterminate truth value. On the other hand, if nomic closure is true, there is only one way the world-states could be (and thus only one way the events these records correspond to could be) given the lawlike natural facts and the world's state at time t[8]. This also makes it implausible to claim there are not determinate truths about these states.

Thus, (B), (D), and (F), and their time reverses should be ruled out as plausible combinations.

Lastly, it is important to note here that these two incompatibilities place limitations on semantic asymmetry. In the absence of nomic and ontological closure, it is possible to hold a semantic asymmetry (as discussed in 3.V), but if there is either nomic or ontological closure in either direction, semantic closure is entailed. Since nomic asymmetry is impossible, semantic asymmetry could occur only in the absence of nomic and ontological closure or in the presence of an ontological asymmetry.

(ii) A: Ontologically, Nomically, and Semantically Closed

This is the view that a) the future exists, b) there is exactly one set of events compatible with the laws of nature and the world's state at time t (which themselves need not be necessary) and c) the truth-values of propositions about that future are determinate.

Since the future exists, one can only plausibly be an eternalist. However, all views of lawlike natural facts are compatible. Notably this combination is especially amenable to the BSA, since the supervenience base can contain not only all the events in the eternalist's ontology, but also all of the determinate truth values of these events.

However, it might be argued that (A) is in tension with human experience of agency. This experience might give us reason to think that (A) is false, since it might be thought to be difficult to reconcile with agency. However, even if the future is closed in all senses, agents might still be said to influence the future. This is to take a compatibilist stance on free will (most famously explained in Frankfurt 1971 and Strawson 1962) and hold that free will is compatible with causal determinism. It remains an open question, though, whether determinism in conjunction with both nomic and semantic closure poses a more serious challenge to free will than determinism alone.

A′: Applying these notions to the past, we get the view that the past exists, it is deterministic, and there are determinate truth values about it. This seems to be the

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[8] It is important to note that this is a distinct claim from saying that there is more than one set of past states compatible with the record and the lawlike natural facts — there may have been more than one set of initial conditions that produced this record. See 3.IV.

view that fits with common intuitions that there is only one set of past events that are settled and thus unchangeable, and that we can make true claims about them.

There is an asymmetry of *influence* that is key to the relationship between (A) and (A′). Influence goes from past to future, and this is related to perceived agency: there is no experience of having agency towards the past, despite the conditions of closure being the same.

What could justify this asymmetry? Two things could be the cause of this. Firstly an *objective direction of time* could ground a real direction of influence from past to future, creating a physical asymmetry.

Secondly, a merely felt *experience* of time passing towards the future may giving us a sense of choice between what we perceive to be possible outcomes due to epistemic limitations (though as in (A) there is only one such set of possible outcomes).

Thirdly, we claim to have *knowledge* of the past but not of the future; a key reason many believe that the past is closed is the existence of physical and mental records that we do not possess for future events. For example, we have books, fossils, buildings, videos, and memories of past events, which give us evidence of what the past was like. These might then be used to ground the truth of propositions.

However, according to (A), there are records in the future that are just as real as those in the past that can ground propositions, too. Due to ontological closure the objects and events of the future exist, and these objects and events are just as real as the records we have of the past. Thus, we have no reason to treat them any differently regarding their ability to act as truthmakers. The fact that we cannot know about them is nothing to do with the existence, determinateness, nor truth value of these records.

(iii) C: Nomically Open, Ontologically and Semantically Closed

On this view the future exists and statements about it have determinate truth values, yet it is nomically open or indeterministic. This combination leads to the classic dilemma of 'future contingents' which I mentioned in chapter three. It is difficult to see how this combination works at first, and to me this seems to be because we tend to ground semantic closure in nomic closure or nomic closure in ontological closure, so to go against these familiar forms of reasoning is challenging.

However, if we attempt to divorce them somewhat a plausible view emerges. The key thought that leads to this is that though there is only one way the future *does* turn out, this does not mean that the lawlike natural facts that made it so were deterministic. In other words, though there is more than one set of specific natural facts compatible with the lawlike natural facts and the world's state at time t, there can still be a fact about how things do in fact turn out. On this combination, this can be justified by eternalism; one can say that the future states that exist tell us how the future turns out.

Humeans such as Lewis that endorse a Best System Analysis (BSA) of laws of nature might want to opt for such a combination. The BSA is the view that the laws as the regularities in particular matters of fact in the world such that they are systematised in the strongest and simplest way. Since the regularities supervene on the patterns of events in the world, it is attractive for the BSA as ontological closure means it has events from all times for regularities to supervene on while maintaining that these laws may still be probabilistic (for example the laws of Quantum Mechanics).

Another way this might be cashed out while maintaining a probabilistic governing law theory is the 'Thin Red Line' view (e.g. Malpass and Wawer 2012): that there are multiple different futures corresponding to the possibilities laid out by nomic indeterminism, and they all exist. However, one path (namely, our world) is privileged, as it is the one that actually obtains.

C′: This combination tells us that the past exists, it's nomically undetermined, and there are determinate truth values for statements about the past. This again can be explained by understanding that the fact that an event has a particular outcome does not make it deterministic. Indeterminism simply tells us that there is more than one set of successive states *compatible* with the lawlike natural facts and the world's state at time t. It does not tell us that each of these sets of states *obtain*.

(iv) E: Ontologically Open, Nomically and Semantically Closed

On this view, the way the future will turn out is determined and statements about the future have determinate truth values. This seems to follow nicely from the nomic closure, as if the configuration of the universe is determined a certain way, it seems intuitive that we can say things that are true or false of it based on this fact.

This might pair up with the ontological openness in the following ways, Firstly, one can be a presentist — i.e. hold that only the present exists, and both the past and the future do not — and claim that all of the facts about the present entail truths about the future. This type of view would be especially amenable to a deterministic non-Humean law theory; one that holds that laws of nature are existent in themselves and not merely supervenient on patterns in states of affairs of the world.

Such a view would allow the presentist to ground the truth of future propositions in the combination of the present state of affairs and the lawlike natural facts. Since they are deterministic, it would entail that there is only one set of states, and thus (at least for an ideal knower) to know the present state of affairs and the lawlike natural facts would be to know these states.

However, this is also potentially compatible with a deterministic BSA, since one can have their supervenience base contain not past, present, and future *events*, but past, present, and future *facts*. Since facts about the future have a determinate truth value, the BSA theorist could claim that the laws supervene on them.

Secondly, one can also be a Growing Block Theorist and hold that both the present and the past exist, but the future does not. On this combination the GBT might say that all of the facts about the past and the present entail truths about the future. For example, the world's state at time t and the lawlike natural facts entail that a certain volcano will erupt at 2pm tomorrow; it is then attractive to say that the world is semantically closed, as we can say that it is true that a certain volcano will erupt at 2pm tomorrow, and ground its truth in the entailments of the lawlike natural facts.

E′: The past doesn't exist in the ontological sense but facts about it are both determined and have determinate truth values. Firstly, the past being ontologically open means the only real ontological position that it is compatible with is presentism. Of course, one could hold ontological openness of the past and closure of the future, but this would be very difficult to motivate and seems a very unattractive view.

Secondly, similar arguments for the compatibility of the accounts of lawlike natural facts can be made in this direction.

Thirdly, there are important considerations regarding the argument I made in chapter one regarding the semantic distinctness of presentism and eternalism. With (E) and (E′), the presentist appeals to truths about other times, and they may be difficult to distinguish from the eternalist.

The resolution of the disagreement was that presentists and eternalists quantify over the most unrestricted domain, which for the eternalist includes all time and for the presentist only includes the present. However, if the presentist refers to facts about other times being true, it is unclear whether they are in fact only quantifying over the present.

(v) G: Ontologically and Nomically Open, Semantically Closed

This combination states future doesn't exist, and the laws of nature are indeterministic. However, there are determinate truth values about propositions regarding the future. This is prima facie very strange; it seems in tension with the combination of ontological and nomic closure as it seems hard to see how a future that neither exists nor is deterministic could have every proposition regarding it with a determinate truth value.

On terms of ontology, this combination has a choice between the presentist, branching eternalist, or growing block theories. Problems arise with this combination for the presentist and growing block theorist given the nomic openness and semantic closure. If future states don't exist and we don't know exactly how the future will turn out, how can there be facts about future states? There are no states for these facts to be about, nor laws to determine what these facts will be. Though probabilistic laws can justify some facts about the future, it is impossible for them to justify them all.

However, it is important to remember that the laws of nature being indeterministic does not mean that there can be no facts about the future. It simply means there is more than one set of events that are compatible with the lawlike natural facts and the world's state at time t. This is perfectly compatible with future propositions having determinate truth values: it is possible that there are truths about the way things will actually turn out, even if there is more than one possible set of world-states.

If we take ontological openness as branching eternalism, there are two further ontological alternatives that are compatible with this view.

Firstly, a branching future — where each of the nomic possibilities is realised along different 'branches' — can satisfy semantic closure this combination since there is a matter of fact about what happens at each time on each of the branches.

This also raises the possibility of a supervaluationist approach to the truth of a proposition independent of the branch we are looking at, whereby for a future tensed statement uttered at time t, it is true simpliciter iff it is true on all branches, false simpliciter iff it is false on some or all branches.

Another similar ontological alternative is a shrinking tree or shrinking block view (e.g. Casati and Torrengo (2011)). Roughly, this would entail that at some time t there are many existent futures, some of which become incompatible with the way the world is as time moves on (do they then cease to exist?). These fit with indeterminism

as they allows more than one set of future states to be compatible with the lawlike natural facts and the world's state at time t.

G′: The past doesn't exist or there are multiple pasts, and is undetermined, but every past event has a determinate truth value. The only two generally accepted ontologies compatible with this are presentism and branching eternalism, and thus is far more limited than (G). Again, it hard to see where the truthmakers would be for past propositions for the presentist if the events they are about do not exist, and the laws of nature cannot necessitate their truth in conjunction with the current state of affairs. However, attempts have been made to provide such truthmakers, as I discussed in chapter three. For example, Lucretian presentism posits primitive tensed properties about entities that are instantiated now, and are claimed to be sufficient to ground the truth of propositions about them.

However, for some this might not be a closure of the past worth having, since the truths that we are able to have about the past are not only difficult to obtain but also only probabilistic. Many of the merits that one might want to obtain by having a closed past — temporal asymmetry, predictive power, grounding of lawlike natural facts, etc. — are not given by this combination.

It is also important to point out that this law-based strategy would only really work with governing laws or powers accounts of lawlike natural facts, as any regularity based accounts would find it difficult to ground the lawlike natural facts in the present state of the world alone (as pointed out in chapter 2).

However, taking a branching eternalist view here is also possible. This would amount to there being different past branches that realise different outcomes of the indeterministic laws. The idea of having many actually existing pasts does not seem to be the kind of past we are looking for, as this seems to conflict with out experience. In addition, although it does give us semantic closure (every proposition about every branch has a determinate truth value), this doesn't seem to be exactly the kind of truth we are looking for when we make truth claims about the past. We could use a supervaluationist semantics such that past propositions are true iff they are true on all pasts and false otherwise, but this would likely lead to many propositions being false that intuitively seem true.

Thus, overall, this is an unappealing combination.

(vi) H: Ontologically, Nomically, and Semantically Open

This combination tells us that the future does not exist or there are multiple futures, it is indeterministic, and the truth values of future statements are indeterminate. This might be considered to be the stereotypical open future view; it being open in every sense. Ontologically, this is the view of either the presentist, branching eternalist, or the growing block theorist. The nomic and semantic openness then might appear to fall out of the presentist and growing block theorist's ontology: the future doesn't exist, so there's nothing to ground our truth claims, and we can affect the outcome when it does come in to existence.

However, of course, this is not necessarily true. It may be the case that only one of these senses of openness is sufficient for the openness of the future, and as I have shown in assessing the other combinations there are other open future candidates that seem plausible.

For example, it could be the case that nomic openness is sufficient for the openness of the future and that one holds a Humean view of lawlike natural facts. To hold such a view, one must have some type of closure, for example ontological, leading to (C) or (D). This possibility of Humean lawlike natural facts is difficult to hold on (H), and would require at least an asymmetry in openness in order to have something to supervene on. As noted in chapter two, though, this leads to the unwelcome possibility that the laws might change over time. Thus, proponents of (H) would hold a probabilistic version of a governing law theory or endorse a no laws approach.

On the other hand, it is doubtful whether such views as branching eternalism or the shrinking tree are compatible with semantic openness and thus this combination. What we need for semantic openness is for a proposition about some future state to be indeterminate. However, for any proposition regarding any event on any branch, there will be a matter of fact about it. Branching views tell us that all possibilities are realised according to different outcomes of indeterministic laws, but there is a determinate matter of fact which outcome occurs on each branch.

On the supervaluationist approach, there is a matter of fact about what happens on each of the branches. The outcome is either true simpliciter or false simpliciter. Thus, there are determinate truth values for propositions about the the future.

Thus, regardless of one's specific nomic view, anyone who holds this view faces the same dilemma. On the one hand, the past consists of one set of world-states that actually occurred, and it is unclear how there are not facts about them. On the other hand, the past consists of more than one set of world-states, each set representing different possibilities according to the lawlike natural facts and the world's state at time t. It is also unclear how there are not facts about these branches, since each represents a determinate outcome of the laws.

H′: There is more than one past or it does not exist, it is indeterministic, and the truth values of past statements are indeterminate. If one wanted to hold both (H) and (H′), the possibilities for a temporal asymmetry would be epistemological and physical. For the first option, this would seem to require that semantic closure would have to be true in the past direction as noted for (B′), (D′), and (F′). Thus, this might seem to be off the table. However, it is also possible to claim that there is an asymmetry in 'reasonable belief' as opposed to knowledge. It remains an open question as to whether this would be sufficient to ground the relevant asymmetry.

For the second option, the likely applicable physical asymmetry would be entropic, as discussed in chapter two. Since this is a probabilistic law, it fits in with nomic openness of both the past and future. However, it does require a determinate initial condition of the universe, and some might be uncomfortable with holding semantic openness towards the past given this.

The upshot is, then, that though only one of the three senses of openness is needed to claim that the future is open, some of them seem to be more worth having given one holds specific philosophical commitments. Over the course of this project I have found that:

1. Nomic closure entails semantic closure (4.i)
2. Ontological closure entails semantic closure (4.i)
3. The BSA needs either ontological or semantic closure of both the past and future, or a branching eternalism, to provide the supervenience base for laws and to prevent the possibility of them changing over time (2.V.i, 4.i, and 4.vi)
4. Semantic closure is possible without either of the other types of closure (4.v)
5. There are many ways one can support a temporal asymmetry: through an asymmetry in ontological, nomic, or semantic closure (2.IV, 2.V, 4)
6. The only viable ontological asymmetry is GBT (1.II.iii, 2.V.i)
7. We cannot have nomic asymmetry (2.V)
8. We can have semantic asymmetry, but this is constrained by (1) and (2) (3.V, 4.i)
9. We can have a physical asymmetry (needs another kind of closure to justify it, e.g. ontological or semantic asymmetry) (2.IV)
10. We can have an epistemological asymmetry (needs semantic asymmetry) (3.II)
11. We can have an asymmetry of information (e.g. contained in records) (needs e.g. ontological asymmetry) (3.IV, 4.ii, 4.i)
12. We can have an asymmetry of influence (might require indeterminism plus semantic or ontological asymmetry) (4.ii, 4.vi)

In the subsequent and concluding chapter, I will evaluate the findings I have made regarding each sense of openness and closure of the past and future and their combinations. I will ask which of these senses might make a combination more or less worth having, and what this means going forward for the study of this and related topics.

CONCLUSION

Over the course of this project, I have answered the question of how we should should go about characterising the open future in order to give a more lucid and philosophically useful definition. I have put forward and justified a taxonomy of openness and closure to be used as a methodology for creating a holistic view, rather than advocating a specific position on what an open or closed future actually consists in. This is because my core claim is that it is not enough to claim that one of these senses justifies an open or closed past or future without specifying one's position regarding the other senses of the taxonomy. My justification for this consists in showing that the combination of elements of the taxonomy can turn out to have problems not present in discussion of each element alone.

My second core claim is that we should taxonomise open future views using three aspects of openness and closure: ontological, nomic, and semantic. I present each sense of openness along with both what it entails and its related positions, along with special considerations about philosophical views related to them.

In the ontological sense, the future is closed if it exists; to say the future is ontologically open is to deny this claim. There are three key ontological views that one must consider for the plausibility of ontological openness and closure: eternalism, the growing block theory and presentism. After explaining and motivating these views, I investigated potential objections and how they fit with out best scientific theories, notably the special theory of relativity.

In the nomic sense, the future is closed if it is deterministic. That is, according the lawlike natural facts (those general facts about the world that hold independent of a particular world-state) plus the world's state at time t, there is exactly one compatible set of world-states. I investigated the key nomic views of universalism, the best system analysis, primitivism, powers, and no laws, and explained what nomic openness and closure looked like for each. I argued that the lawlike natural facts could not justify a temporal asymmetry, while the specific natural facts could justify a physical temporal asymmetry in the form of entropic increase.

In the semantic sense, the future is closed if all propositions about the future have determinate truth values; to claim the future is semantically open is to deny this. I argued that this is deeply linked to epistemological closure — the knowledge of all future states — since propositions about future events must have determinate truth values for us to know them.

I argued that conflating or confusing senses of openness can lead to misguided concerns, such as that of Markosian over fatalism in chapter 3. I showed that by applying my taxonomy such concerns can be dissolved, and we can see more clearly how different elements of openness interact.

When we combine each of these senses, we uncover some interesting and important issues regarding their compatibility. We discover that certain combinations become unappealing when one holds certain views of lawhood (e.g. the BSA and Ontological and Semantic Openness) or that certain nomic views are necessary for the viability of ontological views (e.g. Determinism and Presentism).

Thus, considering each sense individually is insufficient for discussion of the open future. Considering one sense without the others not only prohibits an interesting and important dialogue regarding the nature of the openness of the future, but also of all of the ontological, nomic, semantic, and epistemological positions that are relevant to the discussion.

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