The wave theory of time
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Document Version
Peer reviewed version

Citation for published version (Harvard):
Effingham, N 2021, 'The wave theory of time: a comparison to competing tensed theories', Journal of the American Philosophical Association.

Link to publication on Research at Birmingham portal

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The Wave Theory of Time: A Comparison to Competing Tensed Theories

ABSTRACT: This paper introduces a new theory in temporal ontology, 'wave theory', and argues for its attractions over and above existing tensed theories of time.

KEYWORDS: Temporal ontology; presentism; growing block theory; moving spotlight theory; wave theory.

This paper introduces a new theory in temporal ontology: 'wave theory'. Like eternalists, wave theorists believe there are four-dimensional hunks of matter but, unlike them, they deny that everyday objects are identical to those hunks. Instead, when the instantaneous temporal parts of the four-dimensional hunks become present, those temporal parts constitute the everyday objects; such objects move through time similar to how a wave moves through an ocean.

This paper argues that (at least a good number of) tensed theorists should find wave theory attractive. Section 1 introduces some terminology, whilst Section 2 explains the basics of wave theory itself. Sections 3-4 compare wave theory to the most popular tensed theories (presentism, moving spotlight theory, and growing block theory), explaining wave theory’s comparative appeal.

1. The Metaphysics of Time

1.1 Existence Simpliciter

Ostensibly define the concept ‘present existence’. Barack Obama, Billie Eilish, Nikk Effingham, and the Eiffel Tower are all things that presently exist. Dinosaurs, Napoleon Bonaparte, and outposts on Mars are all things that don’t presently exist. ‘Present existence’ is to be distinguished from ‘existence simpliciter’ (Hestevold and Carter 2002: 497-501; Sider 2001: 16-17, 2006; see also Lewis 1986: 3). Temporal ontology concerns whether there are things that exist simpliciter which nevertheless do not presently exist. For instance, eternalists believe that to exist simpliciter in the past/future is similar to existing a certain distance away—just as the Andromeda galaxy exists even though it doesn’t exist here, eternalists say that dinosaurs exist simpliciter even though they don’t exist now. Presentists, on the other hand, believe something exists simpliciter iff it presently exists. Growing block theorists are a middle ground: the past and present things exist simpliciter whilst nothing that is merely future exists simpliciter. (The definitions of these theories are somewhat ‘rough and ready’ (cf Ingram 2019: 11-38), but will suffice for the purposes of this paper.)

‘Existence simpliciter’ is by no means an unproblematic concept (Golosz 2013; Meyer 2005; Savitt 2006). There are also competing ways to understand debates in temporal ontology (Cameron 2016; Deasy 2017; Williamson 2013). Nevertheless, for the purpose of presentation, this paper sets aside those concerns and cashes out the debate in terms of existence simpliciter. (Although I have little
dubt that everything I say below can be translated into terms friendly to the alternative understandings of the debate.)

1.2 Tensed Time

In addition to which things exist *simpliciter*, it is also a live question as to whether time is tensed or not. Time is tenseless iff the fundamentally true propositions never change truth-value i.e. whatever propositions are fundamentally true at one time are fundamentally true at all times. Otherwise, time is tensed.

For example, consider the propositions:

\[ \text{Presently, there are mereological simples arranged Nikk Effingham-wise} \]

and

\[ \text{There were once mereological simples arranged Napoleon-wise} \]

Were such propositions fundamentally true then, since they change truth-value as time progresses, time is tensed. In comparison, the stereotypical tenseless theorist says that the fundamentally true propositions are all tenseless and that their truth-value never varies. For instance, the following propositions would be fundamentally, and timelessly, true:

\[ \text{At 2021: There are mereological simples arranged Nikk Effingham-wise} \]

\[ \text{At 1800: There are mereological simples arranged Napoleon-wise} \]

In that case, time would be tenseless.

Assuming, as seems correct, that truths about what exists *simpliciter* supervene on which propositions are fundamentally true, there are connections between theories of temporal ontology and whether time is tensed or tenseless. Growing block theory and presentism both require what exists *simpliciter* to change over time, thus the fundamentally true propositions must also change over time i.e. time must be tensed. Eternalism, however, entails neither tensed nor tenseless theory. Say that ‘block theory’ is the combination of eternalism with a tenseless theory of time, whilst ‘moving spotlight theory’ is the combination of eternalism with time being tensed.

2. Wave Theory

This paper defends a new tensed theory of temporal ontology: ‘wave theory’. Wave theorists agree with the eternalist that there are things from the past and future that exist *simpliciter*. Indeed, they believe in the same four-dimensional hunks of matter that the eternalist believes in. Where wave theorists disagree with eternalists is over ‘everyday objects’, things like you and me, tables and chairs, mountains and galaxies, artefacts and organisms etc. Whilst the eternalist identifies everyday objects with the perduring four-dimensional hunks of matter, the wave theorist does not. Instead, everyday objects are three-dimensional objects *constituted* by the presently existing temporal parts of those four-dimensional hunks.

For instance, the eternalist says Nikk Effingham is a perduring four-dimensional hunk of matter. The wave theorist denies this, saying Nikk Effingham is instead constituted by the presently existing instantaneous temporal part of that hunk. Consider another example. The eternalist believes Napoleon exists *simpliciter* and is identical to some four-dimensional hunk, \( h_n \), which is now located in the past. The wave theorist denies this. Whilst they agree that \( h_n \) exists *simpliciter*, they deny that Napoleon exists *simpliciter*. For the wave theorist, Napoleon only used to exist *simpliciter*. At the different instants at which Napoleon existed, a different temporal part of \( h_n \) constituted him.
Since no temporal part of $b_n$ is now present, Napoleon not only fails to presently exist but fails to exist simpliciter. It follows that eternalism is false since Napoleon used to exist but does not exist simpliciter.

A referee worried that, so-stated, wave theory is merely a version of moving spotlight theory rather than a wholly new theory. In response, I say that nothing philosophically interesting can hang on a definition. So, by all means, characterise wave theory as a riff on moving spotlight theory and I shan’t complain. But this paper will stick to the definitions just provided, whereby wave theory and eternalism are distinct. (The referee had a further worry. An eternalist *cum* mereological nihilist denies Napoleon exists simpliciter yet they are surely an eternalist! Tinkering with the example avoids this problem. Assume superstrings are the fundamental mereological simples that the nihilist believes in. The disagreement would then concern superstrings rather than French Emperors: the eternalist-nihilist believes superstrings from the past exist simpliciter; wave theorists say instead that superstrings are constituted objects that only ever presently exist.)

All this said, it will turn out to be irrelevant that the things which constitute everyday objects are temporal parts of some four-dimensional hunk. So, to save on words, I will henceforth talk about ‘chunks’ instead of ‘temporal parts of hunk $x$’. Something is a ‘chunk’ iff there exists something else that the chunk is an instantaneous temporal part of.

On this view, everyday objects end up being a bit like waves. Think of an idealised ocean composed of portions of water which themselves do not move around very much. When, over time, a wave travels through that ocean—changing the properties of those patches (from flat/undisturbed to deformed/bulging)—different patches will constitute the wave. My theory says similar when it comes to the ontology of time. The universe is composed of four-dimensional hunks that do not move through time. But, over time, the properties of chunks of those hunks change i.e. they’ll go from being non-present to being present. As they become present, they constitute the everyday objects around us. Over time, different chunks constitute those objects, such that the everyday objects do move through time.

My theory is not the first to think of the present as a wave. Miller’s ‘cresting wave theory’ (Miller 2019) likewise compares time to a wave. And our theories are not worlds apart! But they do differ. Miller’s ‘cresting wave’ moves through history as the result of purely qualitative changes to those things which exist simpliciter—it’s a ‘qualitative wave theory’. My theory makes the wave ontological, not qualitative; it is an ‘ontic wave theory’. Further, given Miller’s theory, the past is permanently altered by having once been present i.e. the past and future are relevantly different with respects to their fundamental properties (Miller 2019: 112-13). The ontic wave theorist, however, will not say that (or, at least, need not); given my theory, once a past chunk has been present, it reverts to how it once was. Finally—and most importantly—Miller’s theory accepts eternalism, for it is a version of moving spotlight theory. My wave theory does not (for, given Napoleon does not exist simpliciter, eternalism is false). Section 4 motivates why we should prefer wave theory to moving spotlight theory, so doubles as an argument for preferring it to Miller’s cresting wave theory.

2.1 Constitution

Where I say that the chunks ‘constitute’ everyday objects, I have in mind the same sort of relation that constitution theorists say holds between statue-shaped lumps of clay and statues (Wasserman 2018: Section 2). According to standard constitution theory, where there are clay molecules...
arranged statuewise, those clay molecules compose two distinct objects, a lump of clay and a statue. Whilst distinct, there’s nevertheless an intimate connection between the lump and the statue—we say the lump constitutes the statue. The wave theorist says the same of the chunks and everyday objects. When I exist, I am constituted by a chunk of a four-dimensional hunk (and so I am distinct from that chunk). Obviously, this paper assumes that you are already amenable to constitution theory. If you are not, then (unsurprisingly!) you are not going to be attracted to wave theory.

There are some differences between how constitution is standardly treated and its wave theoretic presentation. Standardly, constitution theorists say four things:

(i) Objects have spatial parts but no temporal parts.
(ii) The fundamental mereological, constitution, and location relations are three-place relations relativised to a time.
(iii) Constituting objects have different properties from the things that they constitute. For instance, the lump and statue have different persistence conditions (for, if crushed, the lump survives whilst the statue does not) as well as different sortal properties (for the statue is a statue whilst the lump is not).
(iv) Something about the constitution relation explains how two objects can be in the same place at the same time and how they can have different properties. That is, these things are possible because the lump constitutes the statue.

Wave theorists agree with (iii) and (iv), but disagree with (i) and (ii).

Start with the disagreements. Given the hunks have temporal parts, wave theorists deny (i). Indeed, not just hunks but everyday objects have temporal parts. The definition of ‘instantaneous temporal part’ is:

\[ x \text{ is an instantaneous temporal part of } y \text{ at instant } t \leftrightarrow (i) x \text{ is a part of } y; (ii) x \text{ exists at, but only, at } t; \text{ and (iii) } x \text{ overlaps every part of } y \text{ that exists at } t. \] (Sider 2001: 60)

Being constituted by temporal parts of hunks, an everyday object will have that temporal part as a part; exist for only an instant; be such that any part of the temporal part is a part of it (because any such part will constitute some part of the everyday object). Since it is standard to define perdurantism as the thesis that every object has an instantaneous temporal part at every time at which it exists (Sider 2001: 59), wave theory is committed to perdurantism, contrary to standard constitution theory.

(Admittedly, we may decline to accept the standard definition of perdurantism. For instance, the standard definition has problems with presentism and/or gunky time—although Sider (2001: 60-63, 68-73) discusses how to tweak it in light of those problems. Alternatively, we might instead define perdurantism as the thesis that objects persist in virtue of having temporal parts. It is then less clear that all objects perdure in a wave theoretic ontology. Nevertheless, some things—i.e. the hunks—would have instantaneous temporal parts, which is enough to show that, one way or another, wave theory disagrees with the standard constitution theorist.)

There are also disagreements concerning (ii). The wave theorist will say that the fundamental mereological relations, location relations, and constitution relations are dyadic, not triadic. Regarding proper parthood, hunks have chunks/temporal parts as parts simpliciter rather than at a time. Regarding location relations, objects exactly occupy spacetime regions. And, regarding constitution, chunks that constitute everyday objects will do so simpliciter rather than ‘at a time’.
This is all a break with standard constitution theory and its temporally relativised three-place relations. (Note that wave theorists will accept that there are facts about objects having parts at a time in addition to facts about things having parts \textit{simpliciter}. The latter is more fundamental, though; the former facts hold in virtue of the latter. Similar can be said about objects exactly occupying spatial regions at different times.)

Whilst there are some breaks with standard constitution theory, wave theory’s treatment of constitution is still clearly much the same since it agrees regarding (iii) and (iv). Regarding (iii), the wave theorist agrees that objects and the things they constitute will differ over what properties they have. For instance, I have different persistence properties from the chunk that constitutes me, for tomorrow I will presently exist but the chunk will not (although it will still exist \textit{simpliciter}). I have different sortal properties, for I am a person and the chunk is not. I have different mental properties, for I think whilst the chunk does not. These differences, as well as the fact that chunks can exactly occupy the same spacetime region as everyday objects, are explained by the instantiation of the constitution relation. That is: That some chunk constitutes me explains why I can be spatiotemporally superposed with, and have different properties from, that chunk. Thus, (iv) is true.

2.2 The Present Moment

Given wave theory, material objects constitute other material objects. I see no reason why we cannot go further, saying that spacetime regions can constitute other spacetime regions. In particular, just as presently existing chunks of hunks constitute everyday objects, the wave theorist should say that the presently existing maximal slice of spacetime constitutes a further region, namely ‘the present moment’. Call it \textit{NOW}. As time moves on, \textit{NOW} moves with it.

The introduction of \textit{NOW} is itself a point in wave theory’s favour. Given \textit{NOW} exists, and moves through time just as everyday material objects like you and I move through time, the wave theorist can better capture how we talk about the present moment moving through time. When we say things like ‘Time marches on’ or ‘Doesn’t time fly?’ we talk as if the present moment itself is moving through time. Given the existence of \textit{NOW}, this is \textit{literally} true since the present moment is a reified entity changing its position in spacetime as time advances. (This argument for wave theory is developed further in Effingham (MS); for the purposes of this paper, the importance of \textit{NOW} will become clear when we turn to truthmaking in Section 2.4.)

2.3 Explanatory Order

Given wave theory, there is some connection between a thing’s being present and a thing’s constituting a further thing. A natural question arises: Do the facts about which things constitute which other things explain what time is present? Or is it the other way around: Do the facts about what time is present explain the facts about constitution?

Given the version of wave theory I prefer, we should endorse the latter and say that facts about what time is present explain why the chunks constitute everyday objects (and, similarly, why the presently existing slice of spacetime constitutes \textit{NOW}). There are two reasons to prefer this understanding.

Firstly, given that things being present explains their constituting other things, we can explain why otherwise intrinsically identical objects differ concerning whether they constitute a further thing or not. Return to \textit{b}$_n$, the hunk which has chunks that once constituted Napoleon. Take two
chunks removed from one another by an arbitrarily short temporal interval, such that they are intrinsic duplicates of one another. When one constitutes Napoleon and the other does not, it’s a fair question to ask why one constitutes Napoleon whilst the other does not? If a chunk being present explains why it constitutes a further thing, whilst the other chunk being non-present explains why it constitutes nothing, then we have a simple and straightforward answer to that question. Whereas, if it were the other way around—and their constituting a further object explained why the time that is present is present—tricky questions would arise as to why the chunks which were intrinsic duplicates nevertheless differed over whether or not they constituted something.

Secondly, if constitution explains presentness, we end up with a problem distinguishing wave theoretic worlds from certain (admittedly quite strange!) block theoretic worlds. Consider \( w_1 \), a wave theoretic world like our own. Since wave theory is true, a single class of simultaneous chunks, \( \chi \), is presently such that its members constitute further objects. Assume (for reductio) that those chunks constituting objects is what explains things being present—that is, time \( t \) being present is metaphysically explained by there being things which both exist at \( t \) and constitute further objects. Compare \( w_1 \) to a bizarre block theoretic world, \( w_2 \), where \( w_2 \) nevertheless agrees with \( w_1 \) regarding the ontological facts. That is: the same four-dimensional hunks that exist at \( w_1 \) also exist at \( w_2 \); the members of \( \chi \) constitute further objects at \( w_2 \), just as they do at \( w_1 \); at both \( w_1 \) and \( w_2 \), only the members of \( \chi \) constitute further objects. Clearly, \( w_2 \) would be a bizarre world for it is weird that only the members of \( \chi \) constitute further things at that world, but there is nothing in its description that is logically contradictory.

Ex hypothesi, \( w_1 \) and \( w_2 \) are different (for one is tensed and the other is tenseless), yet they nevertheless agree regarding merely ontological facts. It follows that more facts than the merely ontological facts are needed to explain why a world is tensed. Since facts about one object constituting another are merely ontological facts, such facts cannot explain why any given time is present, contrary to our assumption. Hence, by reductio, facts about constitution do not explain facts about presentness (nor why time is tensed). (Note: This argument is similar to arguments about worlds that have a ‘frozen’ present (Cameron 2015: 80-89; Fine 2005: 287; Leininger 2015: 732-36).)

A natural follow up question cum objection is to ask of my preferred theory how it explains what is present if constitutional facts do not play that role? I confess, I have no good answer. But, this isn’t problematic since all tensed theories are faced by this problem (see also Cameron (2015: 108-110)). For instance, imagine a competing tensed theorist said nothing explained which time was present; the wave theorist could say likewise. Or imagine the explanation was instead that a slice of the spatiotemporal manifold instantiated Being Present; the wave theorist can say likewise. And so on.\(^1\) Wave theory faces no special difficulty that other tensed theories avoid. Since this paper is

\(^1\) A referee had the following concern. A Forrest-style view (q.v.) endorses:

**LOCUS**: The present is present in virtue of being the locus of causal activity.

In Section 4.2, I argue that wave theory is less revisionary than its competitors because it need not accept **LOCUS**. But, if wave theory does not accept **LOCUS**, then this Forrest-style tensed theory can explain presentness in a way that wave theory cannot.

However, given the dialectic, this is not a problem. **LOCUS** faces analogues of the challenges for thinking constitution grounds what time is present. For instance, if some time is the locus of causal activity, why not qualitatively similar, arbitrarily earlier, times? Or imagine a block theoretic world at which, weirdly, causation only takes place at one time and all other times are causally inert: isn’t that world tenseless even though only one time is the locus of causal activity? Either these problems are surmountable, or they are not. If they are not, **LOCUS** is false. If they are, then
only concerned with wave theory’s appeal to other tensed theorists, we can set this question/objection aside.

2.4 Truthmaking

I end my exposition of wave theory with an examination of how it handles truthmaking. This is of particular importance when it comes to how the theory performs compared to its competitors. To do this, we need to first discuss two things: (a) what I call ‘c-predication’ and (b) the block theorist’s theory of truthmaking.

First, introduce ‘c-predication’. Return to considering standard constitution theory and the statue and the lump. According to standard constitution theorists, constitution is explanatory. If a lump, \( l \), constitutes a statue, \( g \), then \( g \) exists because \( l \) constitutes it. Already, the standard constitution theorist must tread carefully. If an existential fact about some \( x \) is explained by some more fundamental fact, then \( x \) cannot appear in that more fundamental fact (for to explain the existence of something without circularity, that something cannot appear in the explananda). So the explanation for \( g \)'s existence cannot be that \( l \) constitutes \( g \) rather, some fact (or facts) about \( l \) (and not about \( g \)) explains \( g \)'s existence (and \( l \)'s constituting \( g \)). Such facts might be facts about, e.g., \( l \)'s shape, \( l \)'s being sculpted by some particular artist, and \( l \)'s being comprised of some specific material.

I will lay aside the exact details and say that the conjunctive predicate which \( l \) falls under in order to constitute \( g \) is its ‘c-predicate’. Use the notation \( Cx \) for the c-predicate that is such that the thing falling under it constitutes \( x \). For example, \( l \)'s being \( Cg \) is what explains both \( g \)'s existence and \( l \)'s constituting \( g \).

Note that c-predicates are associated with the specific names of the things that they constitute. It's built into the c-predicate that the thing falling under it constitutes exactly this or that thing rather than merely that it constitutes 'some thing or another' of the relevant type. Something being \( C \) necessitates that it constitutes \( g \), not just that it constitutes some statue qualitatively identical to \( g \). One worry with this is that, since it’s reprehensible for the fact explaining \( g \)'s existence to feature \( g \), then it’s also reprehensible for that more fundamental fact to feature the c-predicate associated with \( g \). That is: We might worry that there’s something circular about explaining \( g \)'s existence by reference to the fact that something is \( C \). But this isn’t a problem. Compare cases of constitution with cases of composition. Given I’m composed of some atoms, \( a_1, a_2, \ldots \), there are two collective plural predicates, \( F_1 \) and \( F_2 \), such that the following two propositions are true:

\[
\begin{align*}
\langle \text{There are some atoms, } a_1, a_2, \ldots, \text{ such that } a_1, a_2 \ldots \text{ being } F_1 \text{ explains why there is something composed of the atoms} \rangle \\
\langle \text{There are some atoms, } a_1, a_2, \ldots, \text{ such that } a_1, a_2 \ldots \text{ being } F_2 \text{ explains why they compose Nikk Effingham} \rangle
\end{align*}
\]

These are two different facts and \( F_1 \) and \( F_2 \) are two different predicates. For instance, assume mereological universalism is true. In that case, \( F_1 \) is merely the existence predicate and \( a_1, a_2 \ldots \) existing is explanation enough for why \( a_1, a_2 \ldots \) compose some further thing. But clearly that doesn’t explain why the atoms compose Nikk Effingham. The explanation for my existing is quite different. I won’t offer any proposal as to what that explanation might be (although \( F_2 \) is presumably some highly extrinsic predicate about much more than how the atoms intrinsically are or what their

the wave-theoretic analogues will likewise be surmountable; in that case, the wave theorist can explain presentness in terms of constitution and there is no reason to endorse Locus in the first place.
arrangement is). Regardless of the actual explanation, what’s important is that everyone ‘gets their own’ predicate. My existence is explained by atoms falling under one predicate, \( F^2 \), whilst your existence is explained by atoms falling under some other predicate, and Barack Obama’s existence is explained by his atoms falling under yet a third predicate. And so on for all people (and all other objects too)! In short, we should accept that there are \( F^x \) predicates, such that my atoms are \( F^Nikk \), Obama’s atoms are \( F^Obama \), and so on, and those atoms being that way explains the existence of Nikk Effingham, of Obama, and so on. Whilst the notation involved in \( F^x \) predication may mention names (e.g. ‘Nikk’ and ‘Obama’) that doesn’t mean that a proposition like \( \{ \exists xxF^Nikkxx \} \) can’t explain \( \{ \text{Nikk Effingham exists} \} \). C-predication is exactly the same. The notation for the relevant c-predicate might feature a name (e.g., in \( C^g \’s \) case, ‘g’), but that doesn’t mean \( \{ C^g \text{ exists} \} \) being true can’t explain \( g \text{ exists} \).

C-predicates are equivalent to conjunctions of other predicates. For instance, if \( l \) constitutes \( g \) iff it has a certain shape (\( S \)), was carved by a particular carver (\( R \)), at a particular time (\( T \)), and is unsurrounded by other matter (\( U \)), then:

\[
C^g x = df Rx \land Sx \land Tx \land Ux
\]

Say that the predicates featuring in the conjunction are ‘b-predicates’ of the c-predicate (since they’re ‘bits’ of the c-predicate).

All this in place, we can now return to temporal ontology and examine wave theoretic constitution. When four-dimensional chunks fall under the appropriate conjunction of b-predicates, the chunk constitutes some specific object. Section 2.3 argued that wave theorists should say that being present is one feature that explains why a chunk constitutes a further object i.e. one b-predicate of every c-predicate is the predicate ‘\( \_ \) presently exists’. The remaining b-predicates will be predicates about the mass, size, shape, and other fundamental, physical (and possibly extrinsic) characteristics of the relevant chunk. Say that the conjunction of every b-predicate other than the predicate ‘\( \_ \) presently exists’ is a ‘c-predicate’; use the notation ‘\( C^x \)’ to stand for the c-predicate corresponding to the c-predicate \( C^x \). Each chunk falls under some c-predicate; moreover, that a given chunk falls under some given c-predicate is a fact that never changes. When those chunks become present, they then also fall under the corresponding c-predicate and, thus, come to constitute a further entity.

For example, consider Napoleon and Joséphine. There are two four-dimensional hunks, \( h^n \) and \( h^j \). Take two chunks of those hunks from some instant, \( t \), in 1800 AD when Napoleon and Joséphine were next to one another; call those chunks \( n^t \) and \( j^t \). Were they present, those chunks would respectively fall under the c-predicates \( C^Napoleon \) and \( C^Joséphine \) (and thereby constitute Napoleon and Joséphine). When those chunks are not present (and, indeed, even when they are!) they nevertheless fall under a c-predicate i.e. both \( \{ C^Napoleon n^t \} \) and \( \{ C^Joséphine j^t \} \) are (timelessly) true.

C-predication—and, more specifically, c-predication—does all the work in the wave theorist’s account of truthmaking. The wave theorist provides truthmakers similar to those of the block theorist. That said, consider the block theorist’s theory of truthmaking. Block theorists don’t have a problem finding truthmakers for tensed propositions because they deny that there are any (metaphysically complete) tensed propositions (Skow 2015: 22-27). But, the block theorist acknowledges the need to find truthmakers for true tensed sentences. Consider sentence \( s \): ‘Napoleon
was once next to Joséphine’. Were \( s \) to exist in 2021 AD then it would be true; moreover, it is true in virtue of some tenseless proposition being true. The truthmaker for that proposition (and, by extension, for \( s \)) is a conjunctive state of affairs consisting of the following sub-states:

(i) there exists a four-dimensional hunk, identical to Napoleon;
(ii) there exists a four-dimensional hunk, identical to Joséphine;
(iii) there is a time, \( t \), at which Napoleon has an instantaneous temporal part (call it \( n_t \)) and Joséphine has an instantaneous temporal part (call it \( j_t \));
(iv) \( n_t \) and \( j_t \) are next to one another;
(v) \( s \) exists at time \( t + \) and \( t \) is earlier than \( t + \).

The conjunctive state of affairs of (i)-(v) is the truthmaker for \( s \) (and also the tenseless proposition expressed by \( s \)).

Having explained c-predication and the block theorist’s theory of truthmaking, we can now develop the wave theorist’s theory of truthmaking. Unlike block theorists, wave theorists are tensed theorists who accept that there are tensed propositions. So wave theorists believe (Napoleon was once next to Joséphine) exists; call it ‘(\( \langle s \rangle \)’ for short.

The wave theorist’s truthmaker for (\( \langle s \rangle \)) is very similar to the block theorist’s truthmaker for \( s \). The biggest difference is in (i) and (ii), because wave theorists straightforwardly denies their second conjunct. In steps c-predication! Given c-predication we can swap (i) and (ii) for:

(i') there exists a four-dimensional hunk, \( b_n \); every instantaneous temporal part of \( b_n \)

and \( \mathcal{C}_N a l e o n \),

(ii') there exists a four-dimensional hunk, \( b_j \); every instantaneous temporal part of \( b_j \)

and \( \mathcal{C}_J o s é p h i n e \).

That done, we then translate (iii) into something wave-theoretic friendly:

(iii') there is a time, \( t \), such that \( b_n \) has an instantaneous temporal part at \( t \) (call it \( n_t \))

and \( b_j \) has an instantaneous temporal part at \( t \) (call it \( j_t \));

Conjunct (iv) remains the same. Finally, because we’re interested in a tensed fact, rather than a tenseless fact, (v) becomes:

(v') \( t \) is earlier than \textbf{NOW}.

(i')-(iii') involve some redundancy. For instance, \( n_t \) and \( j_t \) being instantaneous follows immediately from their falling under a c-predicate. Similarly, their being instantaneous temporal parts of certain hunks is not relevant (indeed, the wave theorist could get away with committing only to chunks, dropping any commitment to the composite hunks). Eliminating that redundancy, we get:

There exists a state of affairs such that: there is a time, \( t \); \( t \) is earlier than \textbf{NOW}; at \( t \) there

exist two objects, \( n_t \) and \( j_t \); \( \mathcal{C}_N a l e o n \) and \( \mathcal{C}_J o s é p h i n e \); \( n_t \) and \( j_t \) are next to one another.

That complex state of affairs is a truthmaker for (\( \langle s \rangle \)). Truthmakers for other truths can be constructed in a similar fashion. This also includes present truths e.g. the truthmaker for (Presently, Nikk Effingham exists) is the conjunctive state of affairs of there being an \( x \) such that \( \mathcal{C}_N i k k x \) and \textbf{NOW} being simultaneous with \( x \). By making the truthmakers for all truths the same, whether they’re past, present or future, wave theory avoids pitfalls that, say, growing block theory falls into—see Heathwood (2005) and Miller (2018).
This completes the exposition of wave theory. The remainder of this paper motivates wave theory by comparing it to competing tensed theories of time. Given space constraints, it is not possible to compare wave theory to every such theory. I limit my attention to the main three: presentism and ‘standard’ interpretations of growing block theory and moving spotlight theory. (This paper sets aside ‘non-standard’ tensed theories like those discussed by Fine (2005); for instance, Tooley (1997) presents a version of growing block theory whereby fundamental facts are tenseless but what tenseless facts there are is relativised to a time. That would be a ‘non-standard’ theory, similar to Fine’s external relativisation theory (Deng 2017: 1121-22; Fine 2005: 278-80), and so is not considered in this paper.)

3. Compared to Presentism

Compared to presentism, wave theory sells itself on better dealing with presentism’s perennial bugbear: truthmaking. The standard presentist worry is that, since only presently existing things exist *simpliciter*, there is then a shortage of relevant truthmakers. For instance, since Napoleon and Joséphine no longer exist *simpliciter*, no state of affair involving them exists either. So, what is the truthmaker for \( \langle \text{Napoleon once stood next to Joséphine} \rangle \)?

Presentists have suggested responses. Briefly recap some options. Some presentists (Baia 2012; Merricks 2007; Sanson and Caplan 2010; Tallant 2009, 2010; Tallant and Ingram 2015) deny that presently existing truthmakers are needed, whilst others say that we should just deny that there are past/future truths (Dawson Forthcoming). More commonly, though, presentists instead try to find truthmakers that presently exist. The presentist might believe there are sets of propositions (or some such) acting as *ersatz* times (Bourne 2006; Crisp 2007; Emery 2017). Or perhaps everything is contingently concrete, turning into an abstractum when we normally think it ceases to exist (Orilia 2016; Sullivan 2012; Williamson 2002, 2013). Or perhaps our haecceities remain in existence even when their associated object has ceased to be (Keller 2004; Ingram 2019). Or perhaps the world contingently instantiates ‘Lucretian’ properties e.g. *Being such that World War II occurred* (Bigelow 1996; Tallant and Ingram 2020). Or perhaps the world stands in a peculiar ‘used to instantiate’ relation to the uninstantiated property *Is such that World War II is taking place* (McKinnon and Bigelow 2012). Or perhaps the world instantiates a ‘distributional property’ (Cameron 2011). Or perhaps God’s memories and thoughts are the relevant truthmakers (Rhoda 2009). Options abound!

This paper does not argue that all of the above views are mistaken or flawed—a gruelling rehash of the existing literature would add little to the debate. But it is clear to me that, whilst some presentists are wholly satisfied that one of the above solutions works, many philosophers are not and are discomforted by each solution. Such philosophers might be currently self-ascribing presentists who buy into one of those responses, in spite of such worries. Or, they might be philosophers attracted to presentism but who cannot bring themselves to endorse it because of this discomfort concerning truthmaking. It is to both categories of philosophers that wave theory is aimed at. In short: Wave theory is attractive compared to presentism assuming one believes presentism has problems with truthmaking. And, given the ongoing debate about presentist-friendly theories of truthmaking, I take that audience to be reasonably sized.

But there is an obvious complaint. Wave theory might be able to scratch a truthmaking itch that presentism has trouble reaching, but it only does so by relying on things anathematic to the
presentist enterprise—namely, the four-dimensional hunks! It’s reasonable to worry that this is a deal breaker. After all, the presentist must have a reason to not believe eternalism even though eternalism solves the truthmaking problem. So why not think that wave theory is likewise ruled out on similar grounds?

Wave theory is more attractive than eternalism because, whilst both wave theory and eternalism can solve the truthmaking problem, wave theory can better respect the presentist’s worries about the existence of past and future things. Consider the sorts of intuitions driving one to become a presentist:

1. Non-present things don’t exist simpliciter.
2. Non-present material objects don’t exist simpliciter.
3. Non-present events and states of affairs don’t exist simpliciter.
4. Napoleon, who long ago ceased to be, doesn’t exist simpliciter; similarly for other past and future entities that don’t presently exist.

Stereotypically, presentists accept each of (1)-(4). However, these intuitions can come apart. There are already self-described presentists who accept some, but not all, of (1)-(4). Orilia (2016: 589-90) describes a ‘moderate presentism’ according to which (1) and (2) are false but (3) is true. Zimmerman (2011) (see also Longenecker (2018)) describes a presentist theory whereby the only objects that exist are those which presently exist (i.e. (2) and (4) are true) but the past and future points of the spatiotemporal manifold nevertheless exist (i.e. (1) is false). So there are already philosophers, claiming to be presentists, who are willing to give ground on exactly which of (1)-(4) is true. Whilst wave theory denies (1), (2), and (3), it agrees with the stereotypical presentist that (4) is true. Thus, wave theory can appeal to such presentists willing to make concessions similar to those Orilia and Zimmerman make.

Moreover, there is a lot to be said in defence of the idea that (4) is the pre-theoretical core grounding the entire presentist enterprise. When the presentist dismisses the existence of non-present things, they have in mind dismissing the existence of dinosaurs and outposts on Mars (Markosian 2004: 48-49). And these are all things the wave theorist agrees do not exist simpliciter. The extra things added into the wave theorist’s ontology, i.e. the hunks of four-dimensional matter, don’t feature in our folk ontology at all; admitting their existence is not to admit the existence of something we intuitively repudiate, for those hunks are things which the folk haven’t even thought about to begin with.

Just as I am not arguing that every possible presentist response to the problem of truthmaking is doomed, neither am I arguing that every presentist should concede that (1), (2), and (3) are false. Indeed, some presentists are committed to (1), (2), and (3) being true e.g. existence presentists who believe the property Being present is identical to the property Being existent (Tallant 2012, 2014). Rather, what I am arguing is simply that some presentists will follow Orilia and Zimmerman in recognising that the intuitions driving them towards stereotypical presentism may instead drive them towards a slightly different theory. Such presentists—if they are also worried about how presentism handles truthmaking—should now see the attractions of wave theory.
4. How do we know now is now?

Section 4 considers the two other popular theories of time: moving spotlight theory (MST) and growing block theory (GBT). The comparison with both focuses on the ‘Presently Present Problem’.

4.1 The Presently Present Problem

Given both GBT and MST, the past exists *simpliciter*. Thus, Napoleon exists *simpliciter*. Back in 1800 AD, Napoleon is thinking ‘I presently exist’ (and thinking it *simpliciter*, in the same way that an instantaneous temporal part of Napoleon thinks *simpliciter* on the block view). But Napoleon is wrong—he is not present. And if Napoleon is wrong on this matter then perhaps we are wrong about being present (indeed, given there will be many more times that I am wrong than I am right, I am *probably* wrong about it being present). Since it’s unthinkable that we are wrong about it currently being present, something has gone awry. This is the Presently Present Problem (Bourne 2006; Braddon-Mitchell 2004; Merricks 2006). (There are more recent versions of the problem (Builes Forthcoming; Lam Forthcoming; Russell 2017), but this paper deals only with the ‘classic’ version, just introduced.)

Wave theory offers an escape for, given wave theory, Napoleon doesn’t exist *simpliciter*. He used to exist, but no longer exists; all that exists is some hunk of four-dimensional matter that was once intimately related to Napoleon via the constitution relation. So Napoleon isn’t thinking. Indeed, no chunk thinks. Standard constitution theorists say that people think but that the lumps constituting them do not think—wave theorists will say the same about chunks i.e. that they are the wrong kind of thing to think. So, no entity both exists in the past and is also thinking ‘I presently exist’. Problem solved!

4.2 Extant GBT/MST Solutions

Wave theory solves the Presently Present Problem, but defenders of GBT/MST propose their own solutions. So the question arises: Why should a potential GBT/MST believer switch to wave theory given the availability of competing answers?

First, consider some of GBT/MST’s proposed solutions. We might accept that past objects exist *simpliciter* but place constraints on what can be successfully predicated of them. Perhaps nothing can be predicated of past objects. Or perhaps we are limited to saying only what past objects are presently like e.g. we can say of Napoleon only that he is deceased and of the Lighthouse of Alexandria only that it is ruined. Given either option, we cannot predicate of past things that they have mass or shape, or—most importantly—that they believe and think. Thus, the Presently Present Problem is avoided. (Correia and Rosenkranz (2013) and Deasy (2015) pursue projects along such lines.)

Either tack undermines GBT/MST, making it impossible to cash out that ‘the past is a volume of space-time’ (as Braddon-Mitchell (2004: esp. 200) puts it). If either nothing can be said about Napoleon or, at best, we can say only that he’s dead, then we cannot say that he is an object spatiotemporally removed from us, lying in the past. How, then, is this GBT/MST? (See also Cameron (2015: 110-14) and Sider (2013: 259-60).) Indeed, limiting predication like this turns GBT/MST into a theory already mentioned above i.e. a presentism according to which things permanently exist, but are contingently concreta, becoming non-concrete/abstract when we’d normally think they cease to be. (Braddon-Mitchell (2013: 358-60) has similar worries.) Having
already argued in Section 3 why we should prefer wave theory to such a presentist theory, we can set it aside here.

So, we must consider alternatives. The alternative that I will focus on is the ‘Unconscious Past Response’: Past objects exist—and are still a certain size, shape, and at a degree of spatiotemporal remove from us—but they are suitably different from similar presently existing objects in so far as (at the least) they do not believe/think anything. Given the Unconscious Past Response, Napoleon is not thinking ‘I presently exist’; since he is not thinking it, he is not wrong; further, since we are thinking that we presently exist—and only presently existing things think at all—then we are assuredly present.

Wave theory should be preferred because it is less revisionary than the Unconscious Past Response. Start by considering some details of the Response. Forrest (2004, 2006) defends it on the grounds that the present is where causal activities take place: Since believing/thinking is an activity, only presently existing people can believe/think. Indeed, this applies to all activities. No one sleeps in the past, lives in the past, coughs in the past, and so on. That is just one defence of the Response. There are others. Forbes (2016) argues that thinking/consciousness is an extrinsic state depending upon there being no more slices of existence that follow. Or we could imagine a simple alternative whereby the tensed theorist baldly asserts that the presence/absence of presentness results in the presence/absence of mental properties. All such claims would underpin the Unconscious Past Response.

Each underpinning claim is a contentious metaphysical claim that adds in extra metaphysical machinery in order to avoid the Presently Present Problem. Were they not contentious claims, it would have to be conceptually incoherent to believe that past/future entities cannot think. But, I fear that this would prove too much, for then block theory would be conceptually incoherent (since, according to block theory, no-one is ‘objectively present’ and yet they think). Whilst the door is open to press that line of attack, I doubt that block theory is false for such reasons and so doubt that the Unconscious Past Response is conceptually necessary—rather, we should see it as a substantive metaphysical commitment.

My argument is not that making this substantive metaphysical claim is itself problematic. It would be hypocritical to do so given that wave theory makes its own bold commitment, namely to presently existing chunks constituting everyday objects. Such a constitutional claim isn’t part of our concept of presentness and so must also be a substantive metaphysical claim.

Instead, to see why wave theory is less revisionary than the Unconscious Past Response, consider what the Response says of people in the past. They are, in effect, zombies, having the accoutrements standardly associated with being a thinking/believing person (e.g. having certain neural properties) but lacking some essential factor that allows them to think and believe. Some take umbrage at the Response making everyone in the past a zombie (Braddon-Mitchell 2004; Miller 2019: 109), but this paper will not follow that line, for even if it’s not inherently ridiculous, the claim that people in the past lack mental properties is revisionary. Standardly, we believe certain physical properties give rise to consciousness. The Unconscious Past Response ignores that standard, saying that an extra ingredient is necessary for such consciousness to arise. Hence, it is revisionary.
Having established that the Unconscious Past Response makes a revisionary claim (and having established what that claim is), I can now make the case for wave theory. We should aim for minimal revisions to what we believe. Both parties agree that some Napoleon-shaped object exists in the past. Regarding that object’s size, shape, neural layout etc., both parties agree. Both parties also agree that the object does not think because of a contentious metaphysical claim revising our standard belief that objects with such properties are conscious. But here’s the rub: Those attracted to constitution theory already said such things. Standard constitution theorists say that lumps of matter (e.g. my body) may have certain physical properties (e.g. size, shape, neural layout etc.) but deny that those lumps are thereby conscious (for I am conscious, not my body). The Napoleon-shaped chunk lying in the past fails to think, but this is only a particular instance of that broader claim which the constitution theorist already believes is true. The failure of the chunk to think is to be expected given the principles of constitution—at least, it is once we add that only presently existing things constitute further objects. So, the constitution theorist already accepts the key principle used to avoid the Presently Present Problem. Those endorsing the Unconscious Past Response do not; they add in a bespoke contentious metaphysical claim to avoid the Presently Present Problem. Hence, the approach of the wave theorist is less revisionary than that of the Unconscious Past Response. Ceteris paribus, it is to be preferred.

An objection to this line of argument is that wave theory smuggles in an extra revisionary claim that GBT/MST need not accept. Wave theorists make the contentious claim that presentness is crucial to constitution—a prima facie revisionary claim that their opponents can avoid. Thus, goes the objection, each theory (wave theory and GBT/MST) accepts a revisionary claim, thus they are as revisionary as one another (or, if you aren’t sure that the two claims are ‘equally revisionary’, it’s at least very murky as to which is the more revisionary).

But this objection is unfair. This paper assumes that one is already attracted to constitution theory. Thus, one is already obliged to answer the ‘Special Constitution Question’: What are the circumstances in which one object constitutes a further object? In the literature, no agreement has been reached as to how to answer the Special Constitution Question. If anything, there is a paucity of proposed answers in the first place. Suggestions have been made by Baker (2000: 95), Doepke (1982), Simons (1987: 238-40), and Thomson (1998) (see Wasserman (2004) for discussion), but it is no exaggeration to say that no answer has become widely accepted. Thus, any answer eventually settled on will be contentious, no matter the details. So, the wave theorist settling on a contentious answer to the Special Constitution Question is no disbenefit to wave theory; since the constitution theorist must settle on some answer, it’s not especially worrying for the wave theorist to settle on their answer. As long as you accept this paper’s assumption that constitution theory is true, wave theory remains less revisionary than the Unconscious Past Response.

(Perhaps one is allergic to the very idea of presentness being a factor in constitution. But I don’t see why. What could be wrong with thinking that presentness might be a factor in constitution, particularly once we take on-board the issues in the ontology of time discussed in this paper? Certainly, a wave theoretic answer to the Special Constitution Question is, at the least, consistent with what certain constitution theorists want to say. For instance, some constitution theorists say that constitution depends upon the intentions of agents (Baker 2000, 2002; Einheuser 2011; Renz 2016; Sutton 2012); elsewhere, I’ve presented a wave-theoretic version of that theory (Effingham 2021).) Further, wave theoretic versions of extant answers might even be superior to non-wave
theoretic versions. Consider one example, the Doepke-Simons view whereby one thing constitutes another iff it could be a substratum of the constituted object’s total destruction. Wasserman offers a counterexample: a lump of organic matter is totally destroyed by slowly removing its parts and incinerating them; if those parts are replaced slowly enough, then the person the lump constitutes will nevertheless survive. Thus, we get the wrong result that a person constitutes a lump of organic matter because the former can be a substratum of the latter’s destruction (Wasserman 2004: 698-99). A wave theoretic answer in the same spirit would be:

\( x \) constitutes \( y \) iff (a) \( x \) mereologically coincides with \( y \) and (b) there are times at which \( x \) exists simpliciter whilst \( y \) does not exist simpliciter.

No matter what we incinerate, the chunks that constitute a person will exist simpliciter eternally. Thus, a wave theoretic version avoids Wasserman’s counterexample. So, making presentness a factor in constitution may prove independently attractive to the constitution theorist. This concludes my discussion of why we should favour wave theory to growing block/moving spotlight theories adopting the Unconscious Past Response.

There are alternative solutions to the Presently Present Problem other than the Unconscious Past Response. Some run a problem similar to that for the Unconscious Past Response. For instance, Button’s version of GBT revises the ‘real-as-of’ relation (Button 2006, 2007). In a standard eternalist model, later moments are real as of earlier moment and vice versa. Button’s solution to the Presently Present Problem revolves around making the ‘real-as-of’ relation asymmetric rather than symmetric; given Button’s GBT, later moments are no longer real as of earlier moments. How this feeds into solving the Presently Present Problem need not detain us, for it is enough to recognise that Button is explicitly revising some feature of reality—namely, the logical properties of the ‘real-as-of’ relation—that the wave theorist need not. For reasons similar to those concerning the Unconscious Past Response, we should prefer wave theory because it is the less revisionary option.

(Not every response to the Presently Present Problem need fall afoul of the same problem. For instance, it’s not clear to me that Cameron’s response (2015) does. So, to prefer wave theory, we would already have to disprefer such options on independent grounds. But that is, arguably, the case—see, e.g., Miller (2017, 2018).)

4.3 Compared to MST

Wave theory is to be preferred to MST vis-à-vis the Presently Present Problem. Further, I suspect that wave theory captures any benefit MST is meant to offer. (Which is unsurprising, for they are very similar theories after all! Indeed—as noted in Section 2—you may wish to treat wave theory as a sub-species of MST.) The only issue that MST and wave theory differ over is whether or not eternalism is true: MST says ‘yes’, whilst wave theory says ‘no’. But it’s not clear to me what motive would drive one towards eternalism that cannot also be captured by wave theory’s quasi-eternalist hunks. For instance, imagine you endorsed eternalism because you believed that only eternalism can provide adequate truthmakers for past and future truths. As Section 3 has shown, since wave theory can provide a truthmaking scheme without eternalism, that’s no reason to favour MST. Similarly, I see little reason to think that MST better handles issues with relativity than wave theory (for more on wave theory and relativity, see Effingham (2021)).
4.4 Compared to GBT

The same line of argument I ran against MST works against GBT. That is: one reason to favour wave theory over GBT is how it solves the Presently Present Problem; it is then unclear what other reason there would be to prefer GBT; thus, we should prefer wave theory.

The only reason I can think of to endorse GBT instead of wave theory is that wave theory, unlike GBT, commits to future things existing simpliciter. If the growing block theorist believes there is something to be gained by avoiding the existence of such future things, then GBT would have a leg up on wave theory. Presumably, the main motive in the vicinity would be to capture the alethic openness of the future (i.e. allow for the truth-values of propositions about the future to change as time passes) (Briggs and Forbes 2012: 257; Diekemper 2005, 2007). Even though wave theory denies that future everyday objects exist simpliciter, given Section 2.4’s theory of truthmaking, the future chunks existing simpliciter is enough to fix the truth-value of all propositions about the future. So, given wave theory, the future would be alethically closed, not open. In short, the worry is that if we wanted to avoid making the future alethically closed, we should prefer GBT over wave theory.

But this is a misplaced worry. Even if you were wedded to the idea of the future being open, we can easily imagine an amenable version of wave theory. Thus far, the version of wave theory I’ve discussed has it that the four-dimensional hunks that exist simpliciter never change, having chunks which exist in the past, present, and future. But this is a negotiable part of the theory. We can meld GBT with wave theory and instead say that reality is a growing block, such that past and present chunks exist simpliciter but (presently) nothing exists simpliciter in the future. The wave theoretic twist is that it is only chunks/hunks that continue to exist simpliciter once they become past; only the four-dimensional hunks grow over time, not the everyday objects. The everyday objects are, instead, constituted by the different chunks of the growing hunks, always located at the forefront of the growing block. (And so those everyday objects cannot be located in the past erroneously thinking that it’s the present moment i.e. there’s no Presently Present Problem.) But nothing—no everyday object and no chunk of any four-dimensional hunk—lies in the future, so there is no worry that the future is fixed by the existence of future chunks. So, there’s no reason the wave theorist can’t offer a unique wave theoretic spin on growing block theory. The resulting theory, in better overcoming the Presently Present Problem, should nevertheless appeal to existing growing block theorists.

(Again, following on from comments in Section 2, I’m not wedded to wave theory being some radically different theory from GBT or MST. If you think that wave theoretic versions of those theories are more attractive than their traditional counterparts, that is conclusion enough for me.)

5. Conclusion

This paper has introduced wave theory and argued that it has benefits over and above other tensed theories of time. Those tensed theorists with anterior commitments conflicting with wave theory (e.g. the existence presentist’s commitment to (1)-(3)) may not be convinced. However, the theory will nevertheless appeal to a broad range of existing tensed theorists.
Acknowledgements

Thanks to Henry Taylor and those who attended my talks at Collège de France, the University of St. Andrew’s Arché seminar, and the University of Kent’s Joint Session conference. Thanks also to the anonymous referees, particularly those from this journal.

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