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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 the former, they deny that everyday objects are identical with 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, and section 2 explains the basics of wave theory itself. Sections 3 and 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*

Ostensively 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 do not 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* that 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 does not exist *here*, eternalists say that dinosaurs exist *simpliciter* even though they do not exist *now*.

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Presentists, on the other hand, believe something exists *simpliciter* iff it presently exists. Growing block theorists occupy a middle ground: the past and present things exist *simpliciter* while 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 doubt 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, that is, whatever propositions are fundamentally true at one time are fundamentally true at all times. Otherwise, time is tensed.

For example, consider the propositions:

⟨Presently, there are mereological simples arranged Nikk Effingham-wise⟩

and

⟨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:

⟨At 2021: There are mereological simples arranged Nikk Effingham-wise⟩
⟨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 the question of 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; that is, 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, while 'moving spotlight theory' is the combination of eternalism with time being tensed.

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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 the eternalist believes in. However, wave theorists disagree with eternalists over 'everyday objects', things like you and me, tables and chairs, mountains and galaxies, artifacts and organisms, and so on. While 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 with some four-dimensional hunk, h_n, that is now located in the past. Wave theorists deny this. While they agree that h_n exists *simpliciter*, they deny that Napoleon exists *simpliciter*. For wave theorists, Napoleon only used to exist *simpliciter*. At the different instants at which Napoleon existed, a different temporal part of h_n constituted him. Because no temporal part of h_n is now present, Napoleon not only fails to presently exist but fails to exist *simpliciter*. It follows that eternalism is false because 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. By all means, characterize wave theory as a riff on moving spotlight theory, and I will not 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 that constitute everyday objects are temporal parts of some four-dimensional hunk. To be brief, 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 idealized ocean composed of portions of water that themselves do not move around very much. Over time, when 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 things are similar when it comes

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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; that is, they will 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 consider the present a wave. Miller's 'cresting wave theory' (Miller 2019) likewise compares time to a wave. 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 that exist *simpliciter*—it is 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; that is, the past and future are relevantly different with respect 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 important—Miller's theory accepts eternalism, for it is a version of moving spotlight theory. My wave theory does not accept eternalism (for, given Napoleon does not exist *simpliciter*, eternalism is false). Section 4 motivates why we should prefer wave theory to moving spotlight theory and thus 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. While distinct, there is 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 relativized 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 while the statue does not) as well as different sortal properties (for the statue is a statue whilst the lump is not).

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(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 is an instantaneous temporal part of y at instant $t =_{df}$ (i) x is a part of y; (ii) x exists at, but only, at t; and (iii) x overlaps every part of y 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, and 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 the definition 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—that is, the hunks—would have instantaneous temporal parts, and this is enough to show that, one way or another, wave theorists disagree 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. 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 relativized 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 *simpliciter*. The latter is more fundamental, though; the former facts hold in virtue of the latter. Something similar can be said about objects exactly occupying spatial regions at different times.)

While 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

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different persistence properties from the chunk that constitutes me: tomorrow I will presently exist but the chunk will not (although it will still exist *simpliciter*). I have different sortal properties, for I am a person and the chunk is not. I have different mental properties, for I think while 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 and say 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 'NOW'. As time moves on, NOW moves with it.

The introduction of NOW is itself a point in wave theory's favor. Given 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 NOW, this is *literally* true because the present moment is a reified entity changing its position in spacetime. (This argument for wave theory is developed further in Effingham (n.d.); for the purposes of this paper, the importance of 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 NOW). There are two reasons to prefer this understanding.

First, 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 h_n, the hunk that 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 is a fair question to ask *why* one constitutes Napoleon while the other does not. If a

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chunk being present explains why it constitutes a further thing, and 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 that were intrinsic duplicates nevertheless differed over whether or not they constituted something.

Second, 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. Because wave theory is true, a single class of simultaneous chunks, χ, 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 that 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 χ constitute further objects at w_2, just as they do at w_1; at both w_1 and w_2, *only* the members of χ constitute further objects. Clearly, w_2 would be a bizarre world for it is weird that only the members of χ 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 is not problematic because *all* tensed theories are faced by this problem (see also Cameron 2015: 108–10). 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. Wave theory faces no special difficulty that other tensed theories avoid. As this paper is only concerned with wave theory's appeal to other tensed theorists, we can set this question/objection aside. Before we set this aside, there is one last consideration. A referee argued that a Forrest-style view on presentness might leave an outstanding challenge. A Forrest-style view endorses (*q.v.*):

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

The line of argument I have just run has it that, when faced by a Forrest-style view, wave theorists should simply accept LOCUS. However, things I say below rule this out; in section 4.2, I argue that wave theory is less revisionary than its competitors on the

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grounds that it allows us to deny Locus. The referee's worry is that I cannot have it both ways: I cannot, on the one hand, take seriously a version of wave theory according to which Locus is true while, on the other hand, recommending that such a theory be accepted because it allows one to deny Locus.

This is a fair complaint. Fortunately, given the dialectic, it is ultimately not a problem. Locus itself 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: is that world not 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 the wave-theoretic analogues will likewise be surmountable, the wave theorist *can* explain presentness in terms of constitution, and there is no reason to consider Locus to be a challenge in the first place.

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 first need to discuss two things: (a) what I call 'c-predication' and (b) the block theorist's theory of truthmaking.

First, to 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. Here 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). Thus, 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, for example, l's shape, l's being sculpted by some particular artist, and l's being composed of some specific material. I will lay aside the exact details and say that the conjunctive predicate that l falls under in order to constitute g is its 'c-predicate'. Use the notation C^x for the c-predicate that is such that the thing falling under it constitutes x. For example, l's being C^g 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 they constitute. It is 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. Somethings' being C^g necessitates that it constitutes g, not just that it constitutes some statue qualitatively identical to g. One worry with this is that, as it is reprehensible for the fact explaining g's existence to feature g, then it is also reprehensible for that more fundamental fact to feature the c-predicate associated with g. That is: We might worry that there is something

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circular about explaining *g*'s existence by reference to the fact that something is C^g. But this is not a problem. Compare cases of constitution with cases of composition. Given that I am composed of some atoms, a_1, a_2, . . ., there are two collective plural predicates, F_1 and F_2, such that the following two propositions are true:

> ⟨There are some atoms, a_1, a_2, . . ., such that a_1, a_2, . . . being F_1 explains why there is something composed of the atoms⟩
> ⟨There are some atoms, a_1, a_2, . . . , such that a_1, a_2, . . . being F_2 explains why they compose Nikk Effingham⟩

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, . . . existing is explanation enough for why a_1, a_2, . . . compose some further thing. But clearly that does not explain why the atoms *compose Nikk Effingham*. The explanation for *my* existing is quite different. I will not 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 arrangement is). Regardless of the actual explanation, what is important is that everyone 'gets their own' predicate. My existence is explained by atoms falling under one predicate, F_2, while 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 explain the existence of Nikk Effingham, of Obama, and so on. While the *notation* involved in F^x predication may mention names (e.g., 'Nikk' and 'Obama') that does not mean that a proposition like $\langle \exists x x F^{\text{Nikk}} x x \rangle$ cannot explain ⟨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 does not mean $\langle C^g l \rangle$ being true cannot explain ⟨*g* 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:

$$C^g x =_{\text{df}} Rx \wedge Sx \wedge Tx \wedge Ux$$

Say that the predicates featuring in the conjunction are 'b-predicates' of the c-predicate (since they are '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; that is, one b-predicate of every c-predicate is the predicate '__ presently exists'. The remaining b-predicates will be

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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 AD 1800 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 $C^{\text{Joséphine}}$ (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; that is, both $\langle C^{\text{-Napoleon}} n_t \rangle$ and $\langle C^{\text{-Joséphine}} j_t \rangle$ 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 do not 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 AD 2021, 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 with Napoleon;
(ii) there exists a four-dimensional hunk, identical with 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

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straightforwardly deny their second conjunct. In steps c⁻-predication! Given c⁻-predication we can swap (i) and (ii) for:

(i′) there exists a four-dimensional hunk, h_n; every instantaneous temporal part of h_n is $C^{\text{-Napoleon}}$.
(ii′) there exists a four-dimensional hunk, h_j; every instantaneous temporal part of h_j is $C^{\text{-Joséphine}}$.

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

(iii′) there is a time, t, such that h_n has an instantaneous temporal part at t (call it n_t) and h_j has an instantaneous temporal part at t (call it j_t);

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

(v′) t is earlier than NOW.

The propositions (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 NOW; at t there exist two objects, n_t and j_t; $C^{\text{-Napoleon}}n_t$ and $C^{\text{-Joséphine}}j_t$; n_t and j_t are next to one another.

That complex state of affairs is a truthmaker for ⟨s⟩. Truthmakers for other truths can be constructed in a similar fashion. This also includes present truths, for example, the truthmaker for ⟨Presently, Nikk Effingham exists⟩ is the conjunctive state of affairs of there being an x such that $C^{\text{-Nikk}}x$ and NOW being simultaneous with x. By making the truthmakers for all truths the same, whether they are 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 Fine's 'nonstandard tensed theories' [Fine 2005]; for instance, Tooley [1997] presents a version of growing block theory whereby fundamental facts are tenseless, but what tenseless facts there are, are relativized to a time. That would be a nonstandard theory, similar to Fine's external relativization theory [Deng 2017: 1121–22; Fine 2005: 278–80], and therefore is not considered in this paper.)

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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 because only presently existing things exist *simpliciter*, there is then a shortage of relevant truthmakers. For instance, because Napoleon and Joséphine no longer exist *simpliciter*, no state of affairs involving them exists either. What then is the truthmaker for ⟨Napoleon once stood next to Joséphine⟩?

Presentists have suggested responses; I will 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, while others say that we should just deny that there are past/future truths (Dawson, 2021). 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 (Ingram 2019; Keller 2004). Or perhaps the world contingently instantiates 'Lucretian' properties, for example, *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 grueling rehash of the existing literature would add little to the debate. But it is clear to me that, while *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 currently be self-defined 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 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. Given the ongoing debate about presentist-friendly theories of truthmaking, I take that audience to be reasonably sized.

However, 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 is reasonable to worry that this is a deal breaker. After all, the presentist must have a reason not to 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 while both wave theory and eternalism can solve the truthmaking problem, wave theory can better respect

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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 do not exist *simpliciter*.
(2) Non-present material objects do not exist *simpliciter*.
(3) Non-present events and states of affairs do not exist *simpliciter*.
(4) Napoleon, who long ago ceased to be, does not exist *simpliciter*; similarly for other past and future entities that do not 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 that 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). Thus, there are already philosophers, claiming to be presentists, who are willing to give ground on exactly which of (1)–(4) is true. While 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 defense of the idea that (4) is the pretheoretical core grounding the entire presentist enterprise. When presentists dismiss the existence of nonpresent 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, that is, the hunks of four-dimensional matter, do not 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 have not 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, for example, existence presentists who believe the property *Being present* is identical with the property *Being existent* (Tallant 2012, 2014). Rather, what I am arguing is simply that some presentists will follow Orilia and Zimmerman in recognizing that the intuitions driving them toward stereotypical presentism may instead drive them toward 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'.

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4.1 The Presently Present Problem

Given both GBT and MST, the past exists *simpliciter*. Thus, Napoleon exists *simpliciter*. Back in AD 1800, 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 being present). Since it is 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 2021; Russell 2017], but this paper deals only with the 'classic' version just introduced.)

Wave theory offers an escape for, given wave theory, Napoleon does not 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 is not 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, namely, that they are the wrong *kind* of thing to think. Accordingly, 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. 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; for example, 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 important—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 is 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, namely, a presentism according to which things permanently exist, but are contingently concreta, becoming nonconcrete/abstract when we would normally think they cease to be. (Braddon-Mitchell

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[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.

We must consider alternatives. The alternative 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'; because he is not thinking it, he is not wrong; further, because 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: Because 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 defense 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 (because, according to block theory, no one is 'objectively present', and yet they think). While 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 is not 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 is 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

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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 is 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 they 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 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. Thus, 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, and therefore they are as revisionary as one another (or, if you are not sure that the two claims are 'equally revisionary', which is the more revisionary is at least very murky).

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. Accordingly, the wave theorist settling on a contentious answer to the Special Constitution Question is no disbenefit to wave theory; because the constitution theorist must settle on *some* answer, it is 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 do not see why. What could be wrong with thinking that presentness might be a factor in constitution, particularly once we take on-board

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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 have 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* while *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. That is, making presentness a factor in constitution may prove independently attractive to the constitution theorist. This concludes my discussion of why we should favor 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 into 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 moments 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 recognize 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 revise. 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 is not clear to me that Cameron's response (2015) does. To prefer wave theory, we would already have to dispref er such options on independent grounds. But that is, arguably, the case—see, for example, 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.

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(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 subspecies of MST.) The only issue that MST and wave theory differ over is whether or not eternalism is true: MST says 'yes', while wave theory says 'no'. But it is not clear to me what motive would drive one toward 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, the fact that wave theory can provide a truthmaking scheme without eternalism, is no reason to favor 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 favor wave theory over GBT is how wave theory 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. Given wave theory, then, 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 have discussed has it that the four-dimensional hunks that exist *simpliciter* never change, having chunks that 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 is the present moment, that is, there is 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

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fixed by the existence of future chunks. There is no reason the wave theorist cannot 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 am 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.

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